Mr Abbott

SCIENTIFIC AMERICAN SUPPLEMENT. No. 658

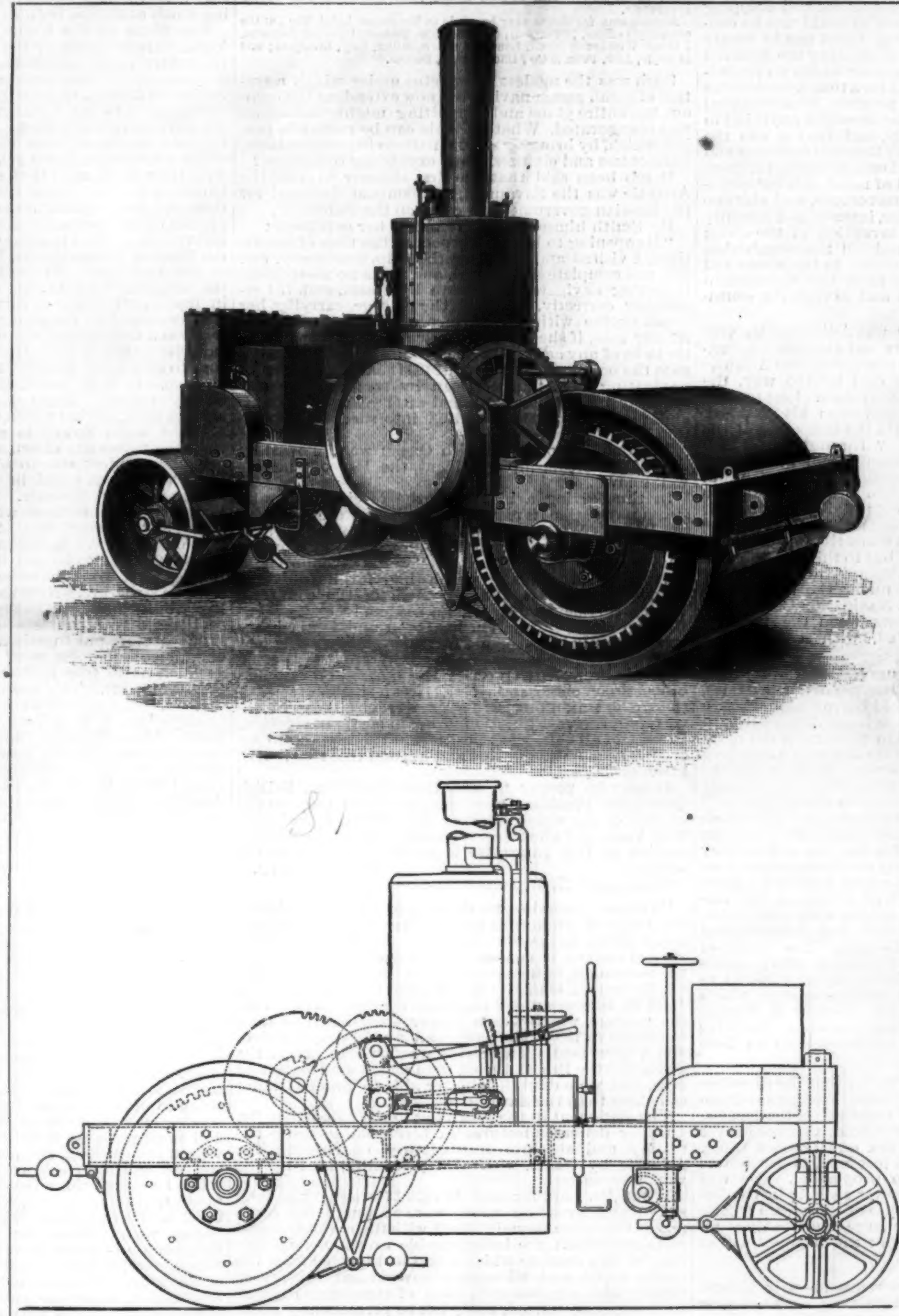
Scientific American Supplement, Vol. XXVI, No. 658. Scientific American, established 1845.

NEW YORK, AUGUST 11, 1888.

Scientific American Supplement, $5 a year. Scientific American and Supplement, $7 a year.

IMPROVED WATER BALLAST STEAM ROAD ROLLER.

The accompanying engravings illustrate a new steam road roller made by Messrs. Barford & Perkins, of Peterborough. It presents several new features, one of which is the application of the water ballast which Messrs. Barford & Perkins have for some years used with much success for small and heavy land and road rollers. This gives a very heavy main roller for road making work, and a comparatively light roller when emptied for traveling. It also, of course, secures a much lower cost per ton of machine in working order. Another feature of the roller is the arrangement by means of which an equal weight per foot of width of roller tread is carried by the front and back rollers. Some difference of opinion is held concerning the load which should be carried by the front and back rollers, but as the steam roller travels backward and forward on the road being made, there seems to be no valid reason against making the load per foot of tread equal on all rollers; and there are, on the other hand, distinct advantages in it; and for the wide roller it is claimed that a better finish in the consolidation of the road is obtained. Whatever the opinion may be in different places, the work done by the roller illustrated at Peterborough is quite satisfactory. As will be seen from the engravings, a vertical boiler and horizontal engine are used. The engine is connected with the main roller by gearing which provides two speeds. The main dimensions of the roller recently at work at Peterborough may be gathered from the accompanying engraving. A slow speed is adopted, and a small engine is sufficient for the work to be done. The weight of the steam roller illustrated is 10 tons 1 cwt. empty, and in working order 12 tons. The large roller is 4 ft. 6 in. in width and 4 ft. 6 in. in diameter. It holds 1 ton 8 cwt. of water. The engine is nominally of 4 horse power, and the boiler of the cross tube type.—*The Engineer.*



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IMPROVED WATER BALLAST STEAM ROLLER.

STEAM NAVIGATION.

In human experience, amid great changes, whether bearing upon political, religious, or commercial interests, the mind does not wholly grasp the full effect at the time, and it is only as time rolls on that the developments magnify themselves by results surpassing all previous expectation. This may be affirmed pre-eminently of steam navigation since the first attempt of Livingston and Fulton to navigate by steam.

Who would or could have estimated the results of such an agency? The same may be said of railroading; who could have embraced the idea that within the lapse of less than half a century this country alone should have in successful operation nearly, if not quite, a hundred thousand miles of railroad, which could only have been effected with the agency of steam propelling power?

For many years after steam propulsion was introduced steam navigation was confined to rivers; the originator never contemplating the possibility even of its adoption to ocean navigation. Many now living can remember the crude structure of Messrs. Livingston & Fulton, who, in 1806, built the first steamboat which successfully navigated American waters; the Clermont, of 160 tons, then ran upon the Hudson River, between New York and Albany. If my memory serves me, the Clermont only made four to five miles an hour, arriving at Albany in some thirty to forty hours.

Some time after, steamboats were constructed to navigate the Sound from New York to New Haven, leaving New York at 5 P. M. and arriving at New Haven the following forenoon at 10 to 12 o'clock, making a passage in sixteen to eighteen hours. It was reserved for a later generation to witness the mighty progress of steam navigation. From the time of the first application of steam to the propulsion of vessels, no thought was entertained of the introduction of steam to ocean navigation until 1832, when the subject was first brought before the public by an American citizen, a graduate of Yale College of the class of 1802, Junius Smith, LL.D., who had resided in London, and engaged in active business pursuits with this country from 1805—a period of more than forty years.

In 1832 he crossed the Atlantic on the British ship St. Leonard, arriving in New York in October, after a passage of fifty-four days. He returned to London in the packet ship Westminster, sailing from New York in December, and making the passage to Plymouth, England, in thirty-two days. These two passages forced upon his mind the idea of transatlantic steam navigation, and writing to his correspondents in New York, under date of London, January 28, 1833, he says:

"Thirty-two days from New York to Plymouth is no trifle. Any ordinary sea-going steamer would have run it in fifteen days with ease. I shall not relinquish the project unless I find it absolutely impracticable."

After giving the subject all possible thought and examination, his mind became thoroughly imbued with the project, and he entered upon it with all the enthusiasm required, first introducing the scheme to leading business men and bankers of London and to shipping merchants engaged in the American trade. The project, being novel, was received with the greatest indifference and scouted as a visionary scheme presenting insurmountable obstacles. These multiplied objections he regarded as the offspring of credulity and

ignorant prejudice, which it was his province to correct and overthrow.

In pursuance of this, he issued a prospectus embodying facts and figures to disprove such objections. This he distributed personally. Not meeting with the slightest encouragement, but, on the contrary, with unqualified ridicule as a visionary project, besides an outspoken opposition from all the sailing packet interest, whose craft would necessarily be endangered if the enterprise should prove a success—nothing daunted with these difficulties, which only served to furnish him with new arguments favorable to his project, and to enlarge his ideas, he issued a second and third prospectus, giving a wider scope on a more extended basis.

This, his first prospectus, contemplated a company with £100,000 capital to build steamers of 1,000 tons, while his third prospectus proposed forming a company with £1,000,000 capital to build steamers of 1,800 to 2,000 tons. These prospectuses presented calculations based upon facts connected with the commerce and shipping interests of the two countries which could not be controverted, and the only remaining point was to satisfy the public of the practicability of crossing the Atlantic by steam. Here was a direct issue for which no precedent was furnished, and it seemed for a time a formidable objection. He knew that the progress of mechanical production in Great Britain far exceeded anything in the history of the human family, and that it was the destiny of genius to work its way through darkness and obstacles to the achievement and consummation of great designs. It was this hardihood of mind, this independence of thought, undaunted perseverance, and abstraction from the prejudices, passions, interest and hostility of mankind, which led to the invention of the steam engine, the spinning jenny, and all the numberless modes of applying mechanical power to the wants and conveniences of society, which form the distinguishing features of the eighteenth and nineteenth centuries.

While Dr. Dionysius Lardner was delivering lectures in Liverpool to prove the futility and absolute impossibility (he called it the chimera) of crossing the Atlantic by steam without replenishing coal by the way, the projector of ocean steam navigation stood alone to meet the objections which were heaped upon his proposal. Nothing can more fully illustrate the imbecility of the human mind in pushing its way through untrodden paths than the history of ocean steam navigation. Although the problem that a vessel might be safely and expeditiously navigated by steam power from port to port in the coasting trade was fully demonstrated, it was universally thought impracticable to cross the Atlantic by the same means. It was a Herculean task to turn such currents of thought; but to this great change his efforts were directed. In accomplishing this he set about organizing a company under the title of the "British and American Steam Navigation Company," by securing a board of directors upon the basis of his third prospectus, as stated, with a capital of £1,000,000.

To further this he waited upon the leading merchants and bankers, soliciting the use of their names, borrowing them as a man would borrow money, with the promise to return it as soon as he could do without. After great labor he succeeded in securing a list of directors; with these he came before the public, opening books of subscription to the stock. Here it may be proper to remark that a more difficult task can scarcely be conceived than the introduction to the British public of a new project embracing such physical objections as the navigation of the Atlantic Ocean by steam for a consecutive number of days, for the reason that they are a conservative and peculiarly cautious people, slow to move, while ready with their vast wealth for great enterprises. Once the barriers of prejudice and distrust are removed, they carry a project with great force. This peculiarity Dr. Junius Smith had learned from over forty years' residence in London. The books of subscription were opened in February, 1836; shares were liberally subscribed, sufficient being allotted to warrant contracting for their first steamship, which contract was made with Messrs. Curling & Young, eminent shipbuilders at Blackwall, London. Relative to this Dr. Smith wrote to his correspondents in New York:

"I have the pleasure to inform you that the directors of the British and American Steam Navigation Company have contracted for the building of the largest, and intended to be the most splendid, steamship ever built, expressly for the New York and London trade. She will measure 1,700 tons, 220 feet keel, 40 feet beam; three decks and everything in proportion. She will cary two engines, of 225 horse power each, 76 inch cylinder and 9 feet stroke. The expense of this steam frigate is estimated at £60,000. These large undertakings require time to mature, but I think the business will at last be done effectually."

The contract for the engines was made with Messrs. Claude, Girwood & Co., of Glasgow, which firm, after completing about two thirds of the work, was obliged to suspend and went into bankruptcy, which proved a serious disappointment and involved a great delay. A new contract was then made with Mr. Robert Napier, of Glasgow, and as the building of the ship progressed, the views of the directors enlarged, resulting in the completion of the British Queen, of 2,400 tons.

The delay consequent upon the failure of the first contractors for the engines, coupled with the importance of a practical demonstration of the feasibility of crossing the Atlantic by steam, determined the company to enter upon a charter of the steamer Sirius, of about 700 tons, for a voyage from London to New York and return. She was dispatched from London April 7, 1838, arriving at New York on the 23d, making the passage in sixteen days' consecutive steaming, encountering very tempestuous weather. She made two voyages successfully, completely demonstrating the feasibility of navigating the Atlantic Ocean by steam. She was soon succeeded by the British Queen, which was dispatched from London in July, 1839, arriving in New York after a passage of fourteen and one-half days.

It may be of interest, as it certainly is of value, as a matter of record, to give the prospectus under which the enterprise, now grown to such mighty proportions, was originated. The following is a verbatim copy of the original prospectus now in possession of the writer:

BRITISH AND AMERICAN STEAM NAVIGATION CO.

Capital £1,000,000, in 10,000 shares of £100 each.

Directors.

Henry Bainbridge, Esq., *Chairman.*

Chas. Enderby, Esq.	Col. Aspinwall, Amer. Consul.
Capt. Thos. Larkin.	Junius Smith, Esq.
Capt. Robt. Locke.	Jos. Robs. Pim, Esq., Liverpool.
Capt. Robt. Isacke.	Jas. Beale, Esq., Cork.

Paul Twigg, Esq., Dublin.
Bankers, Messrs. Puget, Bainbridge & Co.,
12 St. Paul's Church Yard.
Secretary, Macgregor Laird, Esq.

The object of this company is to establish a regular and certain communication by steamships between Great Britain and the United States. The vessels are intended to depart alternately from London and Liverpool to New York. Their average passage will not exceed fifteen days. The company's first vessel, the British Queen, has capacity for 500 passengers, twenty-five days' fuel, and 800 tons measurement goods, exclusive of provisions, stores, etc.

The successful voyages of the Sirius and Great Western steamships having placed the success of the undertaking beyond a doubt, the directors are now preparing contracts for other vessels of similar description to the British Queen, and will be able in 1839 to dispatch their vessels for New York on the 1st and 11th of each month from London and Liverpool, alternately.

Applications for shares may be made to Macgregor Laird, Esq., at the company's offices, 78 Cornhill; to Baxendale, Tathem, Upton & Johnson, 7 Great Winchester Street, London; to I. S. Miller, Esq., Liverpool; and to Boyle, Low, Penn & Co., Dame Street, Dublin.

Such was the modest prospectus under which a system of ocean steam navigation now extending throughout the entire globe and supporting mighty industries was inaugurated. What estimate can be made of a project which, by bringing remote nations in juxtaposition, harmonizes and civilizes, while expanding commerce?

It has been said that the first steamer to cross the Atlantic was the Savannah, a steamboat designed for the Russian government to coast on the Baltic.

Dr. Smith himself makes record of her as follows:

"Happening to be in Liverpool at the time of her arrival, I visited and examined the ship, machinery, etc. She was complete ship-rigged, and made no pretensions to having navigated the ocean by steam, and, if I remember correctly, sailed all the passage, carrying her steam engine with her, as any other ship might do. At any rate, if she used her engine at all, it was too little to be of any account. She was not designed to navigate the ocean. It was not till 1833 that the subject of navigating the Atlantic Ocean by steam power was seriously brought forward, and after years of vigorous and persevering labor, carried into successful operation."

The building of the British Queen was followed by that of the steamship President, the loss of which is well known.

In thus giving a history of the origin of Atlantic steam navigation, it may not be amiss to state that even the Duke of Wellington, with his marvelous powers of thought, in answer to a letter addressed to him by Dr. Junius Smith, replied that he "would give no countenance to any scheme which had for its object a change in the established system of the country." What a commentary on human wisdom!

Ocean steam navigation has been and is a mighty lever, not only in its commercial interest, but in the fact that mechanical forces, when wisely applied, become great civilizers, as they draw the bonds of a common brotherhood closer and closer. Not a single interest of this great Union but is, to a greater or less extent, involved in the vast question of ocean steam navigation. In view of all this, what position in this respect do we occupy as a nation? Nothing beyond third or fourth rate.

It may be proper to add that the Sirius, British Queen and President were consigned and came to the address of the writer's firm of Wadsworth & Smith, in New York, and all the correspondence from the first inception of this enterprise is in the possession of the writer. HENRY SMITH.

Burlington, N. J., June 18, 1888.

[Without intending to depreciate the credit due to Dr. Junius Smith for his persevering efforts to establish ocean steam navigation, it is only just to say that his alleged statement concerning the first ocean steamer, the Savannah, is incomplete. On her first voyage she left Savannah, Ga., May 26, 1819, and reached Liverpool June 19. She was under steam for eighteen days during the passage, which was a longer steaming time than the Sirius in 1838. The Savannah was 380 tons burden, and a slow boat. The Sirius was 700 tons. Both the Sirius and the British Queen were rigged with masts and sails, and were doubtless better able to proceed under sail alone than the Savannah.

The statement in the foregoing to the effect that Dr. Lardner delivered lectures in Liverpool to prove the futility and absolute impossibility of crossing the Atlantic by steam, without replenishing coal by the way, is erroneous.

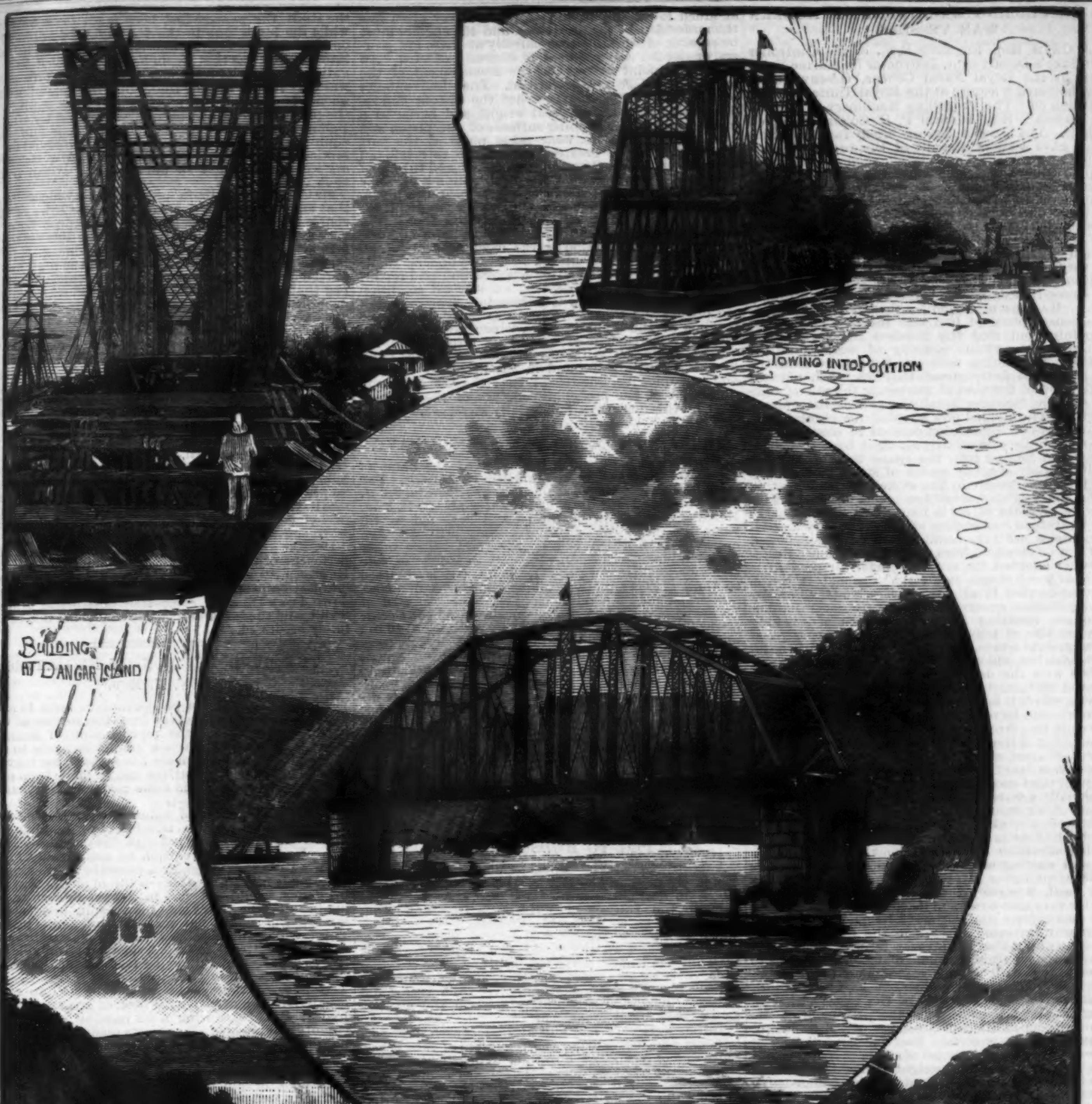
What Dr. Lardner said in 1836-37 was: "The long sea voyages by steam which were contemplated could not at that time be maintained with the regularity and certainty which are indispensable to commercial success, by any revenue which could be expected from the traffic alone; and without a government subsidy of considerable amount such lines of steamers, although they might be started, could not be permanently maintained."

Our impression is the British and American Steam Navigation Co. found out by unfortunate experience that Dr. Lardner's views were absolutely correct. In the early days of Atlantic steam navigation, the only successful lines were those that enjoyed large subsidies from government.—ED. S. A.]

THE HAWKESBURY BRIDGE, AUSTRALIA.

THE accompanying illustrations will serve to convey to our readers an idea of the progress of the immense work of constructing a railway bridge across the Hawkesbury. This bridge is one link of the railway system that brings the cities of Brisbane, Sydney, Melbourne, and Adelaide into communication with each other. We have already given illustrations showing the shape and mode of moving the caissons when constructed. These caissons and cylinders were built in sections, on shore, and were then hauled off and towed to their position. They are oblong in shape, 52 ft. long and 22 ft. wide, and are made of boiler plate. Each section as it was built was made to float, like a huge vessel, to the spot where it was wanted to be sunk. Then quantities of concrete were put in, and the cylinder gradually sank to the position assigned it. The parts of each caisson were put together pretty much as the parts of an iron ship would be, on wooden stays, from which each was launched, and floated by means of steam tugs to its position on the river. It will be understood that the calculations had to be made with the greatest accuracy to secure the sinking of one section of the caisson immediately over another, so that the complete piece might retain a perpendicular position. The bridge will have a total length of 2,896 ft., composed of five spans of 416 ft. each between centers of piers and two spans of 408 ft. each. The bed of the river is made up of mud and soft sand, hard gravel being reached at a depth of 185 ft. below high water. The bridge is to carry a double line of railway, of 4 ft. 8½ in. gauge. As the rails are to be 42 ft. above high water, the total height from the bottom of the piers to the rails will be 227 ft., about the height of our post office tower. Sinking piers to such a great depth has never been attempted before, even in this age of wonderful engineering, and on this account the methods pursued by the contractors for the Hawkesbury bridge (the Union Bridge Company, of New York) are attracting much attention both in Europe and America.

The plans of the Union Bridge Company, of New York, were accepted by the government of this colony, the contract price amounting to £367,000. The original contractors relet the contract as follows: (1) To Messrs. Anderson & Barr, of New York, for the sinking of the caissons; (2) to Mr. Louis Samuel, of Sydney, for the masonry work; and (3) to Messrs. Ryland & Morse, of Chicago, for the erection of the superstructure. Naturally enough the latter gentlemen could not get along with their work until that of the previous contractors had been in some degree finished. As a matter of fact, they had been waiting for some little time for the completion of the masonry. After having worked at some marvelous bridges in America—among others, one over the Niagara Falls—Messrs. Ryland & Morse landed here on 7th April, 1887. Their first task was to commence the building of a pontoon. This was quite a business in itself, and required care and skill second only to that bestowed on the primary object—the bridge. The result is a floating structure of about the same tonnage capacity as the R. M. S. Ormuz. It would require 7,000 tons to sink her. It is 635 ft. long, 61 ft. broad, and 10 ft. deep. It is in watertight compartments, connected by valves. Until May 25th it had lain on a sunken dock, during which time these valves were open and the water flowed in and out. At extremely low tides the valves are closed after the water has drained out. The object was to obtain automatic action, so that the pontoon could be made to rise or sink by the letting in or out of water. Trestling was erected 35 ft. high. Along this there were two lines of rails, upon which a "traveler" ran. This was of very large proportions, being 75 ft. high, 65 ft. long, and 57 ft. wide. The bridge had to be put together on the top of these trestles, as it would have been impossible to raise it as a whole structure. Now that it is in its place the iron looks light and frail enough, but distance is very deceptive in such matters. Seen close to, or on the ground before put together, the iron has quite a different appearance. Some of the parts, indeed, weighed as much as 12 tons each, and had to be hoisted to a height of 110 ft. This was done by means of two steam engines. The riveted work was made in Glasgow, and the eye bars in New York, by the Union Bridge Company. Piece by piece the ironwork was taken to the top of the staging, put into position, and connected by means of steel pins. There is little or no riveting connected with the work, as it is made purely on the American system of pin connections. When the parts are got into position, a pin is put through them, and the work is finished. The structure was got on rapidly with. The trestle work on the pontoon was only begun some four months since; the traveler about three months ago; and it took about two months to put the iron framework together. On an average there were 60 men employed. The whole span when finished weighed about 1,000 tons. There are six piers, and seven spans will thus be required. Each span is 416 ft. long; the width being 30 ft. From the base of the rails to the top of the highest part of the bridge is [illegible] ft., which by the curving is reduced to 40 ft. at each end, each span being in form something after the fashion of half a circle. On the top of each pier are two pedestals, which are bolted into the stonework. There are two shoe plates on each end of the ironwork of the span, which fit into the pedestals. These are then bolted, and become permanently fixed. But it was one thing to build the span of a bridge on the top of wooden staging on a punt 4,000 ft. away from the intended site, and another to fix it in its place. Many people had visited the works at Dangar Island, and admired both the pontoon and the ironwork upon it, but had failed to see how the bridge portion was to be placed on the masonry columns which, with so much care, had been built for its reception. This was the work which was begun with caution on May 25th, and which, by the exercise of great ingenuity and skill, was brought to a successful termination amid great demonstrations of rejoicing. A strong cable line was fixed from the middle pier, upon one end of which the span was designed to rest, to the jetty at the island. This line was passed four times round a steam winch on board the pontoon, which thus enabled it to travel in a direct line. A start was made about half-past 7 o'clock A. M. The pontoon went off the staging where it had so long lain, smoothly, and even gracefully. The engines gave preliminary shrieks, and soon the immense structure was proceeding slowly forward. It was attended by two or three steam launches, and precautions were taken in the way of providing anchorage and other safeguards. At half-past 10 o'clock the men had got all in position, and were waiting for the tide to lower. This it did gradually, and the span was firmly and surely dropped into position at 12 o'clock. A couple of hours afterward the pontoon had dropped sufficiently to enable the supports to be taken away. It was then quietly slipped from under; and the span, unassisted, was gazed at with admiration. The pontoon was taken back to the island and placed upon its cradle during the evening. It remains there complete for any further work. The task of making another iron span will be begun forthwith. As, with the experience already gained, there will not probably be any delays, it is hoped that there may be another launching in about a month's time. The stone masonry will be finished in about three weeks' time, when all the piers will have been completed, and, if all goes well, the bridge should be erected so that trains can pass over it by the end of the year.—*Sydney Mail.*



AMERICAN BRIDGE OVER THE HAWKESBURY RIVER, AUSTRALIA—PLACING OF THE FIRST SPAN.

THE PROPELLING MACHINERY OF MODERN WAR VESSELS.

H. J. Oram, Esq., Engineer R.N., of the Controller of the Navy's Department, Instructor in Marine Engineering at the Royal Naval College, Greenwich, recently delivered a lecture at the Royal United Service Institution on "The Propelling Machinery of Modern War Vessels." Rear-Admiral P. H. Colomb occupied the chair. The lecturer having briefly introduced his subject, gave a short account of the principal steps that have accompanied the development of war ship machinery, more especially since the introduction of the screw propeller, and briefly described the most important changes which have taken place in war ship machinery during the last eight years, and some of the effects of those changes. Continuing, he said for many years past great attention has been paid to the question of reducing the weight of machinery, and some very successful results have been obtained in this direction. He then proceeded to illustrate some of the most successful examples of this reduction in machinery weight. He drew attention to the saving thus made in the consumption of fuel with the new machinery, and pointed out that the distance the vessel could steam with a certain quantity of coal would be doubled. Mentioning next the boilers, he said the most important development that has taken place is the adoption of the plan of increasing the rate of combustion in the furnaces usually known as the "forced draught." The method now adopted for obtaining an increased rate of combustion consists in closing in the ends of the boilers practically air-tight by a system of screens, and forcing into the space thus obtained a plentiful supply of air by means of steam fans, so that there is an air-pressure in the stokeholds sufficient to balance the weight of about two inches of water. This moderate pressure of air is found to be sufficient to cause the rate of combustion of fuel to be very materially increased, with the result that a largely increased power can be obtained from the boilers. The particular system adopted for working under air pressure is known as the "closed stokehold" system; it is the same plan as used in all our torpedo boats, where its first application occurred. There are several other advantages resulting from this system of working which are also of importance. The ventilating pipes with large cowl heads, which are necessary with natural draught, but which are generally objectionable and interfere with the deck arrangements, can be mostly dispensed with, and the requisite openings through the deck, which it is always necessary to keep as small as possible, can be reduced to a minimum. The power of the ship, too, is practically independent of the force and direction of the wind, which is of great importance in some climates, and the stokeholds are always cool and well ventilated. As regards the effect of the introduction of the forced draught on the coal consumption, theoretically a system of burning the fuel by a powerful blast of air should have the effect of limiting the amount of air, always considerable, which passes through the fires to the atmosphere without assisting in the combustion of the fuel, but simply carrying away and wasting a certain amount of heat, and is therefore conducive to efficiency. As regards the boiler itself, however, there has been no improvement for very many years in its efficiency as a generator of steam from coal, although its power has been very greatly increased, in fact, in the former respect, there is no doubt that the present form of boiler with circular furnaces often of small diameter is inferior to the old type with roomy rectangular furnaces, in which much more space could be obtained for the intimate mixture and combination of the gases, with a resulting gain in efficiency. With the present triple expansion engine and steam pressures of 150 to 160 lb. per square inch, it is certain that for large boilers of the present type, any increase of steam pressure would result in an increased total weight of machinery, owing to the increased weight required for the boilers being more than would be saved by the reduction in size of engine, and the gain in economy through the increased pressure, if the present type of engine were retained, would be very small. Also any endeavor to again increase the efficiency of the engine by changing the type to the "quadruple expansion" would be of little use unless accompanied by a considerable increase of steam pressure. The power of modern vessels has to be concentrated in large boilers, owing to the limitations of space and weight, and it appears as if no very considerable increase of working pressure were practicable with our present materials and type, for the shells of these large boilers would become too thick to be properly worked. Another feature of the last few years has been the trial again of what is generally called the tubulous boiler, in which the steam is generated by the hot gases in contact with a series of tubes only, with the omission of the shell, furnaces, and combustion chamber of the ordinary boiler. In our new vessels double-ended boilers are now used both for economy of weight and saving of space. These are necessarily very long, and with the high temperature of steam now used, any considerable differences of temperature between the various parts of the boiler lead to unequal expansion and severe strains, and for this reason all such boilers are now provided with feed water heaters. All the boilers for the fast cruisers recently designed are on this principle, including those for the Blake and Blenheim. These latter will be the first double-ended boilers fitted in our vessels with four furnaces at each end. They will be the largest and most powerful boilers we have, each of them generating sufficient steam for 3,350 I. H. P.; their dimensions are over 15 feet in diameter and 18 feet long, and to prevent these very large boilers being used for the ordinary harbor work of the vessel, such as for electric lighting, distilling, and drill purposes, an auxiliary boiler with two furnaces is fitted in one of the boiler compartments. In connection with the boilers, the adoption of an important fitting may be mentioned, which is a sequel to the surface condenser, and an extension of the same principle. This fitting is what is known as the double distillation condenser, by the use of which nearly all the scale will be kept out of the main boilers, a supply of fresh water being obtained sufficient to make up the loss which occurs when cruising at ordinary speeds. One of the principal points to be attended to in the design of engines for modern war ships is the fact that, while they have to be capable of obtaining a high maximum speed when required, yet most of their steaming is done at much lower speeds, and at powers very often less than one-tenth of the maximum, and the engines must be capable of working economically at these low powers, or else the coal required is seriously affected. An important point as regards the arrangement of the engine should be next described. The disadvantages of the horizontal position are that the pistons and reciprocating parts are of great weight, and borne to a large extent by the rubbing surfaces of the piston and cylinder, so that great wear takes place at the part where it is of the greatest importance to retain an accurate and perfectly steam-tight joint, and this must cause loss after the engine has been running for some time, by the direct passage of steam past the piston when worn. In the modern engines on the triple expansion principle this action certainly occasions loss in a much less degree than with the old, simple engines, but the vertical position is the most natural for an engine; it avoids this uneven wear of cylinders, all its parts are more accessible for examination and repair, and the engine can be kept in an efficient condition much more readily than if horizontal. The weight of the pistons and other reciprocating parts in this case is taken at the main bearings, which are constructed especially for such work. Since its introduction, the vertical engine has without exception been fitted in all first-class battle ships, and in the first-class cruisers, and it cannot be questioned that the efficiency and durability of the propelling engines of these vessels have by this means been materially increased.

NEW ADDITIONS TO THE FRENCH NAVY.

A dispatch boat, which has received the name of La Rance, has just been launched at Lorient. The dimensions of La Rance are as follows: Length, 213 ft. 4 in.; beam, 35 ft.; draught of water aft, 16 ft. 3 in. Her displacement is 1,597 tons, and her engines will work up to 745 horse power. La Rance will carry ten guns, four of which will be revolvers. Two other dispatch boats of the same type are in course of construction at Cherbourg and Rochefort; it is proposed to employ all three in colonial service. A first-class cruiser, named the Cecille, has just been launched at La Seyne, near Toulon. The dimensions of the Cecille are as follows: Length, 468 ft. 4 in.; beam, 50 ft. 10 in.; and depth, 35 ft. 5 in. Her displacement is 5,570 tons, and her mean draught of water 20 ft. 10 in. She is built entirely of steel. Her engines will work up to 6,500 horse power with a natural draught, and up to 9,600 horse power with a forced draught. She is expected to attain a minimum speed of 19 knots per hour. She will carry fifteen accessory boats, two of which will be steam canoes, and two torpedoes. She will be lighted with 300 electric lamps. She will carry sixteen guns, besides a number of rapid-firing guns, and four torpedo tubes. Her cost, including equipment, will be 328,000*l.*; in this sum her engines and machinery figure for 116,000*l.*

THE PROJECTED RAILWAY FROM WINNIPEG TO HUDSON'S BAY.

A meeting of the Royal Geographical Society was lately held in the lecture theater of Burlington House to hear a paper by Commodore A. H. Markham on the subject of "Hudson's Bay and Hudson's Strait as a Navigable Channel." Commodore Markham's paper began by describing Hudson's Bay as a large inland sea well outside the Arctic zone, about 1,000 miles in length, north to south, and some 600 miles wide, covering an area of something like 500,000 square miles. The bay was remarkably free from rocks, and its soundings were exceedingly uniform, the average depth being about 70 fathoms.

Storms were very rare and by no means formidable, icebergs were never seen, and fogs were of rare occurrence and of but short duration. The climate on the shores of the bay was, during the summer months, mild and genial, and it was asserted that the temperature of the water was no less than 14 deg. higher than that of the water of Lake Superior. The principal and, as far as was known at present, the only practicable approach to Hudson's Bay in a ship was through Hudson's Strait, a deep channel about 500 miles in length. The strait had an average breadth of about 100 miles, but in the narrowest part it was only 45 miles broad. The soundings in the strait varied from 150 to 300 fathoms, and it was wonderfully free from shoals and rocks.

The paper then went on to describe the voyages to Hudson's Bay from the time of the early navigators down to the present date. Continuing, it referred to the desire of the people of the Northwest to have a seaport on the shores of Hudson's Bay, and to secure the construction of a railroad to connect such a port with Winnipeg or some other equally convenient depot on the new Canadian Pacific Railroad. This achievement would result in shortening the distance of transport for the export produce by one-half, with a corresponding reduction in the expense. The only obstacle to the establishment of the desired port was the belief in the formidable character of the ice that would, as it was said, have to be encountered in Hudson's Strait, and the consequent limited duration of the navigable season. In order to obtain full and accurate information on the question, the government of Canada dispatched in 1884 the steamer Neptune for the purpose of establishing observing stations on both sides of the strait; while her Majesty's ship Alert was dispatched in 1885, and again in 1886, for the purpose of relieving the stations established by the Neptune. The author of the paper sailed with the Alert, and the experiences of the voyage were recounted in the paper, which concluded by stating that the result of all the experience gathered from voyages during two centuries and from observations at the stations was that Hudson's Strait was perfectly navigable and free from ice in August and later in the season. It was to be remembered that the passage had been successfully accomplished nearly every year for the last 200 years, while the vessels that had been employed on the service had been ordinary sailing ships, dependent entirely upon wind and weather. It was very rare indeed that they had failed to get through, and still more rare that any of them had been destroyed by the ice. It appeared from the official records of the Hudson's Bay Company that Moose Factory, on the southern shore of the bay, had been visited annually by ships since 1735, except in 1779. Since Hudson's ship, the Discovery, had entered the strait, the passage had been made over 500 times, while the losses due to the ice might be summed up on the fingers of one hand. Another fact to be taken into account was that steam had now robbed ice navigation of many of its difficulties and dangers, and it was only fair to assume that, with the appliances that science had revealed, as much could be accomplished at the present day as had been accomplished by Hudson, Baffin, Button, and Luke Fox in their rude and poorly equipped fly boats. The vessel to be employed on this service should be specially constructed to resist ordinary ice pressure, and should be able to steam from 10 to 12 knots at least.

Sir Charles Tupper, in opening the discussion, said that any question of increasing the facilities of intercourse between Canada and England must be of the very greatest importance. During the last season the farmers of the Northwest had produced 16,000,000 bushels of grain, and it was stated on the high and impartial authority of the United States consul at Winnipeg that, of the remaining undeveloped wheat fields of America, three-fourths lay to the north of the boundary line. The present outlet for the produce of the country was by means of the new Canadian Pacific Railway and the great inland water system. The establishment of the new route he hardly regarded as a matter of controversy between persons interested in different means of communication, for when the country was even a little less than half developed it would tax all the available resources of transit. The reports from the observatories established by the Canadian government had not taken quite so sanguine a view as Commodore Markham with regard to the navigability of Hudson's Strait, but he considered Commodore Markham's authority as the higher of the two. If it could be proved that there were four or five months of fairly safe navigation through the strait, he had no hesitation in saying that the day was not distant when the railway suggested would be established.

Dr. Rae gave it as his opinion, formed upon the experience of many years, that the navigation of Hudson's Strait was too uncertain for the line of communication proposed. Large, solid blocks of ice came down Fox's Channel, completely obstructing Hudson's Strait, and the ice came at times that could not be absolutely predicted.

THE REPRODUCTION OF NEGATIVES.

By W. H. Rau.*

Comparatively few photographers seem to appreciate the value to be derived from the successful working of a process for the reproduction of negatives. Many believe a reproduction cannot be made to equal the original. My experience has satisfied me that with care and judgment negatives can be made from others that are as good, and, in some cases, better than the original.

Supposing a rare and valuable negative is on thin glass, and needs a large number of prints made from it, and the owner will not risk the only negative he has. Neither can an edition be made ready in time for a publication. Again, a negative is too thin and flat—made in bad weather—is full of detail, but lacks brilliancy, would not care to risk an intensifier, bearing in mind the stains that may result, besides which intensifying would not make it any more brilliant. This can be reproduced, and a brilliant negative result. A small negative is to be enlarged, or a valuable negative is broken and cannot be made again. Even this can be successfully reproduced.

At different times a knowledge of how to make a negative from a negative has been of great value to me. In 1881 and 1882, during a six months' sojourn in the Orient, I duplicated all subjects made while in Egypt, but on reaching Arabia and Palestine, plates were getting scarce, and only one plate was used on each subject. Many exposures were made under unfavorable conditions, in rain, cloudy weather, etc., as an itinerary had been mapped out, and a certain amount of country had to be gone over each day, and views had to be made under all conditions, good and bad.

Nearly all of these I reproduced on my return, and will show you to-night some of the results, with a print from the original plate and one from the reproduction, side by side. Only recently I came into control of a large collection of plates of India, some of which were made high up in the Himalayas, many miles from a railroad, where travel is expensive and difficult. A few of the choicest plates were cracked and broken. Some of these, which had no chipped edges, but were broken clean, I have reproduced. Sometimes a reversed negative of a choice subject is wanted for some photo-mechanical process.

Having briefly outlined where reproduction was a help and a necessity, we will take up the first part of the process—that is, the making of the positive. Having carefully studied the character of the negative, its color, unevenness, dense portions, etc., carefully clean the back, and have ready a deep printing frame, a size larger than the negative. Have in this a piece of crystal plate glass, free from bubbles and scratches. Then arrange the negatives in the center of the frame, being careful to brush away with a blender all filaments and grit, and place the plates to be used for the positive face down in contact with the negatives. Place a dark pad on this, and put in the back, and gently press the springs into position. All is now ready for the exposure, which I have always made with a Carbutt lantern, measuring about eighteen inches from the side of the lantern, and making a mark, using the oil lamp, as I found this the most regular and reliable, as it can be turned up to nearly the same brilliancy each time of using. The time of exposure varies of course with the density of the negatives and the rapidity of the plate used. I prefer using a slow plate for the positive, one that will develop with ferrous oxalate, such as Carbutt's A or B plates, unless a very dense negative is to be reproduced. I have used recently on dense negatives some Belgian plates that were rapid, also a few Seeds, 22 to 25, as they develop a fine gray color with the ferrous oxalate. I also prefer using a plate a size larger than the negative, in this way avoiding thin edges. Should the negatives be of average good density, about 30 to 40 seconds will be the right exposure with an A plate. If one end of the negatives is thin, shade this by moving between it and

* Read before the Photographic Society of Philadelphia June 6, and extracted from the *American Journal of Photography*.

the light a cardboard, cut to suit the unevenness. If certain portions of the center are dense, cut a round hole in a cardboard and move this in front of the plate and the dense portions, and keep it in motion, giving the necessary extra exposure to bring up the detail which might otherwise be lost.

Having properly exposed the plate, mix a developer consisting of eight parts of oxalate of potash (saturated) solution to one part of iron (also saturated) and twenty drops of a 20 gr. solution of bromide of potassium. The image will, of course, appear slowly, but will build up with an evenness that is essential to success. This should be continued until the image is entirely covered, even the highest lights, so that all detail in every portion of the plate is brought out; then wash and fix it as usual.

The weak developer well restrained gives a soft, even, gray image, full of detail, without too much vigor. In case a thin, flat negative is used, use an A plate, and place the frame 36 inches from the light, and expose proportionately double what it would be at 18 inches, and get as much brilliancy as possible in the development; sometimes, when the original is very flat, ending with a developer consisting of oxalate of potash four parts, iron one part, which will give it snap and vigor. Should it be the intention to enlarge the resulting negative, the positive for this purpose should be less dense than for contact use.

Having dried the positive, carefully spot out any pin holes with a fine pointed brush, and do any other retouching the picture may need, such as strengthening dark portions, etc. Any scraping away of objects not wanted should be done on the positive, such as a crack from a broken negative.

I have with me a positive made from a broken negative, which was in three pieces, and one corner entirely gone, broken *en route* from India. I carefully laid the pieces together in a printing frame and brought them in close contact, then placed the plate, a size larger than the negative, in position and during the exposure moved the frame slowly from side to side in front of the light, to lessen any shadow which might be thrown by the crack. I placed this positive in the hands of Mr. H. Parker Rolfe, a member of this society, who has obliterated the cracks, removed a cow which had strayed in on the edge of the picture, and filled in a corner which was a blank.

The making of the negative is next in order, and I proceed to make the exposure the same as in the positive, supposing the negative is to be the same size, and used for silver printing and ordinary purposes. Should the reproduction be wanted for use in phototyping, photogravure, or any of the processes requiring a reversed negative, then the negative must be made in the camera, placing the positive in position with the film side turned from the lens. Where enlarged negatives are intended, they must be made in the camera, with a short focus rectilinear lens, or a camera with a very long draw. Experience alone will give you the proper time of exposure. It will vary with the density of the positive and the rapidity of the plate used. Here, as before, in making the positive, judgment should be used in measuring the distance from the frame to the light, as a dense positive can be brought to fifteen inches, and a very thin one as much as thirty-six inches, from the light. In this part of the process I use pyro. developer in preference to oxalate, although the Oriental subjects which I will show are all made, both positives and negatives, with ferrous oxalate on Carbutt's A plates. But I find, since making them, a better knowledge of development has been gained, and the results with pyro. are surer than with iron.

I generally begin the development as if the plate were overtimed, using a weak soda and pyro. with a trifle of bromide, and adding soda or pyro. as the subject and conditions may suggest.

The development is similar to that of an ordinary exposure made in the camera. One must notice the detail, the general appearance, and progress the same, if the result is to equal an original negative. I have found that the most difficult part of the process is to secure a positive of the proper density and color. It must be rather over-exposed and gray in color, with all detail apparent without straining the eyes to see it. I always judge the density by daylight, and never use a positive that is yellow, as it is very deceiving in its density, and usually gives an unsatisfactory result. While I admit there are negatives that cannot be well reproduced, I believe they are the exception, and not the rule. Hardness or chalkiness is likely to occur to the beginner, as he is apt to make the positive brilliant in all cases, when really this is not necessary, excepting where a weak, flat negative is used.

Cleanliness, freedom from dust, and good judgment, combined with skill in development, are necessary to obtain the best results.

A NEW METHOD OF MEASURING THE TIME OF EXPOSURE GIVEN BY PHOTOGRAPHIC SHUTTERS.

The methods employed for this purpose known to me are three—viz., Photographing a swinging pendulum, and calculating the length of exposure from the width of what might be called the "blur" on the image. This method was described in *Anthony's Bulletin* of March 26, 1887. It is open to the objection that the velocity of the moving part is not sufficient to give an indication from which exposures of less than $\frac{1}{100}$ or so of a second can be calculated with any satisfactory approach to accuracy. The author who describes the experiment could see no blur—the image appeared perfectly sharp, and he seems, therefore, simply to have assumed a blur of $\frac{1}{100}$ inch, and calculated accordingly.

In method number two a revolving hand or pointer is photographed while being driven by clockwork at a uniform speed of one or two revolutions per second. This, besides being open to the same objection as the preceding, involves a special clock with uniform motion, uninterrupted by an escapement, and large special dial.

A third method has been described in which a small hole in a moving card illuminated by the electric light is caused to traverse in front of a small lens fixed on one of the prongs of a vibrating tuning fork. The vibrating image of the hole falls on the sensitized plate, and the number of its vibrations registered is a measure of the time of exposure. This is a scientifically accurate method, but as it involves the use of the electric light and other complicated apparatus, it is not adapted for general use.

The method which I am about to describe is accurate, easy, and inexpensive. In the simplest arrangement, a tuning fork of low pitch, say a C fork, giving 128 vibrations per second, or the octave above, giving 256, has fixed on one prong a spherical silvered bead or a small bulb containing mercury. The fork is placed horizontally in direct sunlight, and the bright dot of light on the bead carefully focused in a camera placed as close to it as possible. A plate having been inserted and the shutter set, the fork is made to vibrate, either by a blow or, better still, by bowing it with a well resined bow. Immediately it sounds, the camera is rotated on its center screw so that the lens sweeps past the bead, and just as it comes about in line with the bead the exposure is given. The result is a wavy line on the plate, each undulation of which corresponds to one vibration of the fork, and the number of undulations appearing divided by the total number per second given by the fork indicates the fraction of a second during which the shutter has remained open. The manipulation is quite easy, but in order to make sure several more exposures may be given on the same plate if a black cloth be hung behind the fork, as there is then nothing to appear on the plate but the undulating line from the brilliant spot on the bead. If the shutter have means for varying its quickness, several degrees of speed may be taken on the same plate.

This method answers quite well for exposures over $\frac{1}{125}$ second. Even $\frac{1}{250}$ second may probably be estimated with considerable accuracy, but under that amount and down to $\frac{1}{1000}$ second a fork giving at least 1,000 vibrations per second is required, and to make the smaller amplitude of its vibrations apparent a different arrangement is necessary. This is represented in the figure, where A is the bright bead fixed in a block

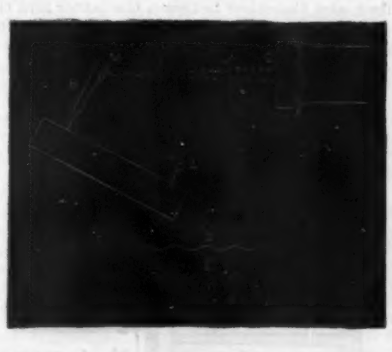
of wood, in which is also fastened the fork, B, with a small mirror, M, fixed on one prong. C is the camera lens. The dotted lines indicate the path of the ray of light from the bead. At each vibration of the fork the angle which the mirror makes with the ray, A M, is varied, and hence the reflected ray, M C, is caused to move up and down through a sufficient amplitude.

The camera and shutter are worked in the same way as before, only it is now the image of the bead on the mirror, M, which is focused. In order to get the camera readily in position for this, the lens and focusing screen may be removed and the camera adjusted in line by looking centrally through it at the mirror. The lens may then be replaced and focusing completed.

When making the exposures a little difficulty may be found in firing off the shutter just at the right time while the swinging camera is in line with the mirror, especially with high pitched forks, when the camera should be moved quickly. To get over this difficulty I have fastened one end of a thread to the trigger of the shutter and the other to a small weight on a table, placed so that when the camera comes to the proper line the thread tightens and releases the shutter, after which the weight follows the camera. This plan also obviates the need of an assistant to set the fork vibrating, as only one hand is now needed for the camera.

The forks I have used with the mirror are G, as sold in the music shops, giving 384 vibrations per second, the octave higher giving 768 per second, and the C above that (C on the second leger line above the treble stave) giving 1,024 per second. These two latter were the ordinary forks cut down and tuned to the proper notes on a piano by grinding as required. Shortening the prongs sharpens the note, thinning them near the bend flattens it. For perfect accuracy the tuning may be done after the mirror is fixed on.

In the figure are some of the results found on testing various speeds of a "Kershaw" shutter. D is given by



the C fork, 128 per second, and shows about six waves, making the exposure about $\frac{1}{21}$ second. E is given by the G, 384 per second, and indicates $\frac{1}{18}$ second. F is from the C, 1,024 per second, and equals $\frac{1}{17}$ second. These last are respectively the longest and shortest exposures to be had with my shutter.

As half a wave could be fairly well estimated, the high C fork gives an approximate measure of $\frac{1}{2048}$ second; but, if necessary, a fork of still higher pitch could be used. Some slight difference in the number of waves appearing while the shutter is opening and closing may arise from differences in the sensitiveness of the plates or the strength of the light. This slight error occurs with all methods of measuring exposures by photography.

The mirrors I use are microscope cover glasses with silver deposited on them, as is done for telescope mirrors, and cemented to the forks (silvered side out) by marine glue. Light mirrors are necessary, as otherwise the vibration period of the fork will be too much altered. As these little cover glasses are not all good, half a dozen or so may be silvered at once; then if it be found that the light from the bead after reflection will not focus to a small point, the mirror is probably not flat, and another can be substituted.—*J. Brown, Br. Jour. of Photography.*

PHOTOGRAPHIC NOTES.

IMPROVING DEFECTIVE NEGATIVES.

Frequently negatives with thin skies may be easily improved so as to produce brilliant prints. On this subject Mr. Edward Dunmore gives the following useful suggestions in the *British Journal of Photography:*

It is well to improve gelatine negatives as much as possible before the application of varnish or other protective surface, strengthening the lights, penciling the shadows, and taking out and putting in generally, which can be done with almost as great facility as on a drawing, for it is astonishing what a deal of rough treatment a dry gelatine surface will permit without suffering any injury. That very usual complaint (which, by the bye, we have not heard much about of late), unequal thickness of film, especially when it is thinner on one side of the plate than the other, may be equalized by the application of blacklead; there may be some difficulty in getting it sufficiently dense—the surface of the gelatine becomes polished and refuses to take the lead and acquire further density. In this case make another application after varnishing; the admixture of a little finely powdered resin will give sufficient tooth, and there will be no difficulty in getting it absolutely opaque. But in a general way a slight dressing of the blacklead is all that is required, and if it can be done before varnishing there is no trouble with it afterward. Blacklead is, so to say, the sheet anchor of the retoucher for either portrait or landscape work. A moist pigment, such as neutral tint or Payne's gray, is also very useful, but requires considerable judgment in its application as to where and how to best lay it on. A figure that has moved away and left but a ghost behind, if in a conspicuous part of the subject, is very ugly left as it is. Therefore a little labor devoted to rubbing down the dense parts and penciling up the thin ones is not thrown away, and a skillful worker will not leave a printable trace of the defect behind. It goes without saying that any serious alteration or patching up of a negative must be done skillfully and judiciously if the work is to be an improvement, for when the doctoring shows it is generally more objectionable than the fault it intended to rectify.

The sky portion of a negative may be thin and so softened off by haze into the distance that it is unadvisable to paint it out, and print in clouds, with a satisfactory result. Under these circumstances some tracing paper on the back of the plate over the sky and distance, the edge of which is serrated and irregular, following the outline of the most dark suitable objects, and strengthened in the sky portion by blacklead applied with a stump, will generally clear it up sufficiently so that clouds may be printed in without making the print too dark or looking muddy. At the same time a negative that allows a slight tint to print through in the sky is preferable to absolute opacity, the resulting picture being more harmonious, and the junction of sky and land rendered absolutely undetectable by the sharpest scrutiny. Shading the sky in printing is sometimes preferable to doing anything to the negative; but this plan is outside the subject now under consideration, which is limited to the treatment of the negatives themselves rather than how to use them when they have been perfected—another matter altogether.

Occasionally the transference of part of a film to make good a defect on a negative of the same subject is an excellent method. This should be effected before varnishing, and is not particularly difficult to do. The part wanted is accurately cut through with a sharp knife and separated from the glass. The defective portion being removed from the negative under repair, a warm solution of gelatine is placed on the bare place and the insertion carefully pressed down, seeing it is exactly adjusted. It is then left to dry, varnished, and finished as usual.

Varnish for Negatives.—The following is a formula for a cheap varnish, which may be used either for collodion or gelatine negatives, and which keeps well:

Bleached lac	32 parts.
Borax	8 "
Carbonate of soda	2 "
Glycerine	1 or 2 "
Water	320 "

Dissolve the borax and the carbonate of soda in 160 parts of hot water, and throw into this solution the lac broken up into fragments. Place the vessel containing this mixture on the fire, and stir until the lac dissolves; allow it to cool a little, filter, and add first the glycerine, then the remaining 160 parts of water. In the course of a few days a deposit has collected at the bottom of the vessel, from which amber-colored liquid varnish is separated by decantation and filtration. Collodion negatives are varnished while still humid, after having been developed and intensified. Gelatine plates are dipped into the varnish for about a minute, or else the varnish is poured over these plates and allowed to remain until it has had time to penetrate the film. In either case a hard, brilliant surface is obtained which is impervious to moisture.—*Photographisches Archiv.*

Eder's Intensifier for Line Wet Plate Negatives.—The negative after fixing and thorough washing is immersed in the following bath:

Nitrate of lead	2 ounces.
Red prussiate of potash	3 "
Water	50 "

Filter.

In this bath the color of the negative soon changes to a yellowish white, which must be allowed to deepen until the proper degree of density has been reached. The chemical action of this bath is thus explained: The silver in the image acts as a reducing agent and deoxidizes the ferridcyanide into ferrocyanide, which unites with the nitrate of lead to form the insoluble ferrocyanide of lead. After being removed from the lead bath, the negative is washed until the drainings give no blue precipitate when sulphate of iron is added. It is then blackened by immersion in a one to six solution of hydrosulphate of ammonia. The action of this

bath is continued until the film is black on both sides. The negative is then washed. If sufficient density was not conferred by the lead bath, the negative may be whitened in a one to ten sulphate of cadmium solution, then washed, and blackened as before with the ammonia, which transforms lead, cadmium, and silver into the corresponding sulphides.—*From the Photographic Negative, by Rev. W. H. Burbank.*

Lange's Toning Bath.—Before the Birkenhead Photographic Association, Mr. Paul Lange stated that the following toning bath operated quickly, was certain in its results, and produced beautiful tones:

STOCK SOLUTION.

Acetate of sodium	180 grains.
Bicarbonate of sodium	90 "
Borax	380 "
Distilled water	80 ounces.

TONING BATH.

Stock solution	5 ounces.
Gold chloride	1 grain.

Mix two hours before using.

If part of bath be retained and mixed with equal proportions of stock solution for a new bath, much finer tones will be obtained.—*Brit. Jour. Photo.*

APPARATUS FOR DYEING, CLEANING, AND BLEACHING TEXTILE MATERIALS.

The apparatus represented in the accompanying figures may be applied in the operations of dyeing, mordanting, bleaching, steaming, scouring, or in any other treatment of cotton, silk, wool, etc., on bobbins or in any other compact form.

The operation is performed either by sucking or forcing liquids through the bobbins, mounted upon hollow perforated tubes or injection spindles.

Fig. 1 shows a vertical section of the machine through the line, *w w*, of Fig. 2, and the line, *v v*, of Fig. 3. Fig. 2 is a plan view. Fig. 3 is a lateral elevation, the section through the vat being supposed to be made through the plane of the dotted line, *u u*, of Fig. 2. In this figure the receiving cylinder is shown in elevation crosswise, while it is mounted in vertical section and supposed to have made ⅛ of a revolution more than its position indicates in Figs. 1 and 2.

Fig. 4 is a horizontal section taken in the plane of the dotted line *z z* of Fig. 1. Fig. 5 is a median vertical section through the line *x x*. Fig. 2 is a median vertical section through the line *y y*. Fig. 7 is a section, on an enlarged scale, of a portion of a bobbin holder.

The liquid designed for one of the operations above mentioned is put into the vat, A. This vat, which may be any sort of a receptacle whatever in cases where it is a question of operations in which the charging or impregnation does not constitute an essential

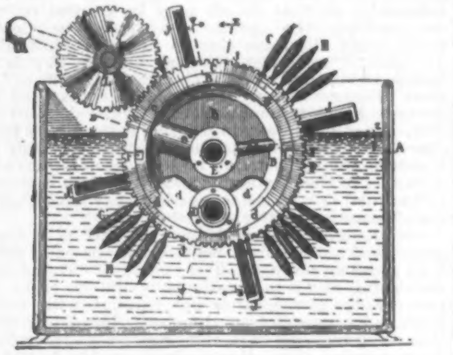


FIG. 1.

point, serves simply as a support to the cylinder, B, which is fixed. The bobbin holder, properly so called, revolves around this, and alternately covers and uncovers the mouths of conduits that are flush with the surface of the cylinder, B.

A charging conduit, D, communicates externally with a force and suction pump, and delivers the liquids to the perforations in the bobbin carrier corresponding to the hollow spindles. This conduit, D, serves also as an extractor when it is a question of a drying operation.

The cylinder, B, is of cast iron, and is in the form of a hollow, truncated cone, closed in the plane of the apex by a disk, *b*, open in the plane of its base. Externally, this disk is prolonged in the direction of the axis of the apparatus by a journal, *b*×, and internally by a pipe, E×, corresponding with the parallel conduit, D×, which latter ends in the charger, D.

The cylinder, B, is supported by the vat through the

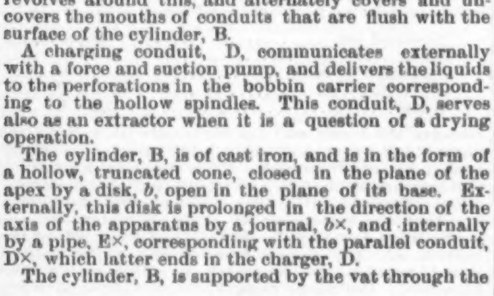


FIG. 2.

journal, *b*×, and the sections of pipe, E and D. Internally, it is partitioned off so as to form several independent chambers. The principal of these are the charging one, *d*, and the extracting one, *e*. The first is lowest down in the vat, and consists of two compartments placed each on one side of the plane of the vertical diameter. The charging conduit communicates with this chamber through the intermedium of a branch pipe, D×.

The extraction chamber, *e*, considered with respect to the arrangement of the cylinder, B, is, by preference, formed in the interior of the upper right hand side of the latter. The extraction and charging chambers do

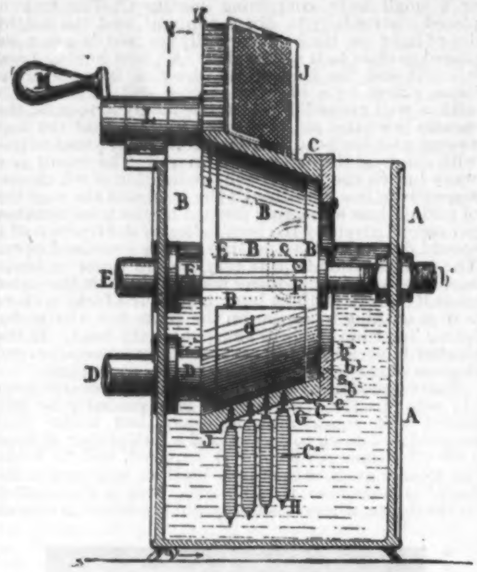


FIG. 3.

not communicate with each other, and with the former is connected the tubular branch, E×, provided with a valve or cock by means of which the chamber can be put at will out of communication with the extraction pump.

A supplementary pipe, E^2, cast in a piece with the cylinder, runs in a direction almost opposite that of

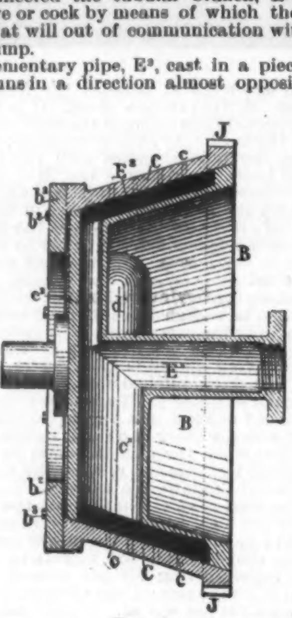


FIG. 4.

the pipe, E×, toward an air exhaust chamber, E^3, situated in the interior. The pipe, E^2, is provided with a cock or valve. Two channels, F, are formed transversely in the external surface of the cylinder, B, one between the air exhaust chamber and the charging chamber, and the other between the latter and the extraction chamber. These channels, which, during the rising of the cylinder, B, are sensibly beneath the liquid

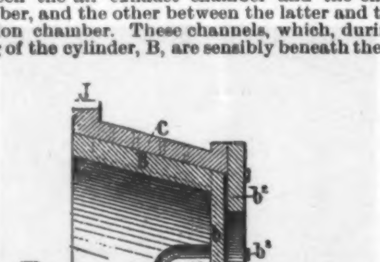


FIG. 5.

in the vat, being covered at the two extremities, are constantly filled with the liquid of the vat and serve to form a joint between the charging and air exhaust chambers. These channels, too, have the following advantage: When the exhaustion pump is utilized as a suction device, a state of rarefaction or a vacuum is produced in the chamber in which the liquid is exhausted and in the interstices between the cylinder, B, and the bobbin carrier. Were they wanting, the coloring matter would be sucked from the charging chamber into the exhaustion chamber, and this would be an inconvenience in practice.

The bobbin carrier, C, consists of a collar that slides over the cylinder, to which it is very accurately fitted. It is held by a ring, b^3, fixed by bolts, b^3, to the end of the cylinder. The apertures for the passage of these bolts form chambers, b^4, in which a spiral spring, *s*, surrounds the shank of the bolt. The initial pres-

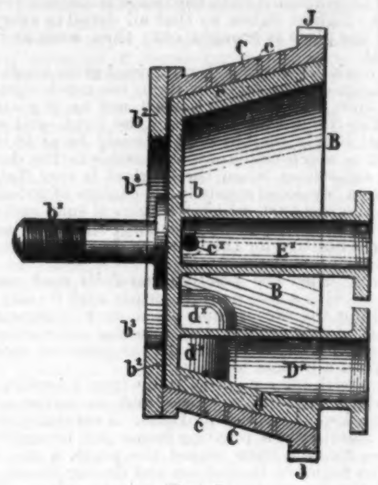


FIG. 6.

sure of these springs is such that when the ring has been applied it is held at a certain distance from the plane of the end, *b*.

The bobbin carrier is provided with a series of apertures, *c*, which form a communication between the internal and external surfaces and serve to give passage to the saturating or exhausting liquid going to or coming from the bobbins, C×. The perforations, *c*, are threaded to receive the hollow spindles, G, in the interior of which is the injecting tube, H, running through the bobbin (Fig. 7). Each spindle, G, carries a spring, *g*, designed to hold the tube in place.

Screens, J, rising radially on the bobbin carrier, in front of each group of apertures, carry radial projections that exceed those of the bobbins and serve to arrest, collect, or thrust aside any foam that accumulates upon the surface of the liquid in the vat, and to keep it at a distance from the bobbins, both at the time of their immersion and their exit from the liquid.

The bobbin carrier is provided at the base with a cogwheel, F, which gears with a wheel, K, which is mounted on a shaft, K, and is set in motion by means of a winch, M.

The liquid is introduced into the vat until it reaches a level situated above the channels, F, and sufficiently above the air exhaust chamber, too, to permit of completely immersing a row of radially projecting bobbins, which, as to their perforations, correspond with the said exhaust chamber.

The suction and force pump is provided with a pipe for returning to the vat all the liquid not absorbed by the bobbins or that should not remain therein. The liquid, under such circumstances, is in constant circulation, and goes to the bobbins from the pump, and conversely.

After the bobbin carrier has been revolved so as to bring a group of its perforations to the upper part of the apparatus, a workman adjusts the bobbins, and then continues to revolve the apparatus sufficiently to completely submerge the entire group and bring them opposite the charging chamber. The pump connected with the charging conduit sucks through the perforations of the bobbin carrier, from the charging chamber, a sufficient quantity of liquid to assure a complete saturation of the bobbins. During this time, the workman adjusts new bobbins upon the following group, and so on.

After their immersion, and when they are emerging from the vat, on the opposite side, the bobbins are in communication with the exhaustion chamber; and a pump, sucking in air from without, frees them by this means of the excess of liquid that they contain.

When the bobbins are to be dried by another machine, the exhaustion chamber is uncoupled, and the

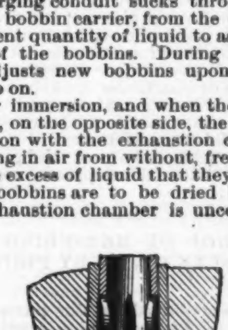


FIG. 7.

operation is reduced merely to the charging and replacing of the bobbins.

In the apparatus figured, as the charging chamber is double, it offers the advantage of presenting the same group of bobbins, so to speak, twice to the action of the charging pump, during the same period.—*Chronique Industrielle.*

DISTILLATION OF PEPPERMINT.*

By ALBERT M. TODD.

"IT has been claimed that the herb peppermint when freshly cut yields more oil than when dried. Is this so? And does the increased yield of oil compensate for the increased expense of shipping the fresh herb to the distiller?"

This question has long been a disputed one, and the discussions have attracted the interest of both scientists and manufacturers. That the importance of making a determination which would be satisfactory and final will be better understood, I will, before stating the results of my experiments, give a brief description of our novel industry, which is rapidly increasing in importance and proportions, prefacing the description with the single remark that distillation is effected with threefold the rapidity from the dry rather than from the green plants.

There are now (in 1888)† cultivated annually in the United States (almost wholly in the States of Michigan and New York) over twenty thousand tons of peppermint plants, yielding over one hundred and twenty thousand pounds of essential oil, thus requiring on the average the production and handling of about three hundred and fifty pounds of plants in the undried state for a single pound of the essential oil. There are now in America about two hundred and fifty small distilleries where the crude or natural oil is produced, each distiller distilling, besides his own crop, the plants of about ten neighboring growers on the average, making the number of persons engaged in the industry as principals over two thousand five hundred, besides a large number of workmen employed in the cultivation and distillation.

The distillers' charge for working up the plants of other growers has by custom been based upon the number of pounds of oil obtained rather than upon the quantity of plants, the present rate in Michigan being twenty-five cents for each pound of essential oil. This custom is most satisfactory to the grower, as he pays only according to his receipts, but it will be seen that it is not equitable for the distiller unless the plants are well dried prior to distillation.

The manufacturing system may be briefly noticed as follows: The plants having been cut when in full bloom are drawn to the distilleries either with or without curing, according to the notion of the grower. The essential features of the distillery are, first, a large boiler for the generation of steam; second, a pair of large wooden vats about six feet in height and of equal maximum diameter, which are connected with the boiler by steam pipes, which enter them at the bottom (two vats being used so that one may be emptied and refilled while the other is running); third, a condensing apparatus, which consists of a series of pipes coated with pure tin, either with or without the ordinary "worm," over which cold water is made to flow continuously, this condensing apparatus being connected with the top of the distilling vat at pleasure by a duplex or "changing valve;" lastly, the receiver, in which the essential oil is collected, the ordinary form of which is a metallic vessel about twelve inches in diameter and three feet in height, from the bottom of which an exterior pipe leads to a height nearly equal with the body of the vessel. Recently I have constructed a much more efficient and elaborate receiver for rapidly separating essential oils both heavier and lighter than water; but as this paper is not intended as a technical treatise on apparatus, it will not be described here.

About three inches from the bottom of the distilling vats are placed "false bottoms" containing many perforations, underneath which the steam enters from the boiler. Upon this perforated false bottom is placed a strong iron hoop having a diameter nearly equal with the vat, and supplied with heavy cross bars. Two pairs of strong chains are secured to this hoop, meeting at the top of the vat in a pair of rings, one of which is fastened on either side of the vat at the top while it is being filled. This apparatus, as will be seen, is for the purpose of drawing the charge from the vats after distillation.

The apparatus being in position, the plants are thrown in by a workman with an ordinary hayfork, while two or three others are engaged in "tramping them down." After the vat is about one-third full a small supply of steam is let in, which softens the plants and greatly assists in packing. When filled the vat is closed with a steam-tight cover, and the other charge being now distilled, the entire amount of steam is turned on in the new one. The steam comes up through the perforations of the false bottom, and is diffused evenly through the plants. The oil is contained entirely in the minute cells in the leaves and blossoms. The action of the steam is twofold. It softens the tissues of the oil cells and at the same time, by its heat, causes an expansion of the particles of oil, so that they burst forth from their miniature prisons, are carried off with the current of steam. The steam, now charged with the essential oil, upon reaching the top escapes into the condensing apparatus, where it assumes the form of oil and water. Separation takes place in the receiver; the water, being heavier, sinks to the bottom, and is forced by the pressure from within upward and out through the exterior pipe referred to. The oil collects on the top and is dipped off at pleasure.

As stated, distillation can be effected with threefold the rapidity from the dry rather than from the green plants, for the effect of drying is to soften the plants, allowing a larger quantity to be used for a charge, while such large charge can also be distilled in one-half the time required for a small quantity of green plants. But many growers, fearing that a loss of oil results from drying, by diffusion in the atmosphere, cannot be prevailed upon to bring their plants to the distilleries other than in a green state. The extemes of difference which I have noticed are as follows: From a charge of 2,000 pounds of dried plants, well covered with leaves and blossoms, thoroughly dried, I have obtained 20 pounds of oil in thirty minutes, an hourly rate of 2 tons of plants and 40 pounds of oil; from a similar charge of very coarse plants, with few leaves and blossoms, distilled in the green state, less than 2 pounds were obtained, requiring one hour for their distillation.

Upon a clear day in September, in the middle of the day, two loads of plants were cut down side by side at the same time. Both loads were immediately raked up in the green state, containing all the natural juices of the plant, then drawn to the scales and weighed. One load was immediately distilled, the other load being spread upon the ground and dried for two days in the sun. At this time the plants had become freed from nearly every particle of moisture, the leaves being so dry and brittle as to break off quite readily in handling. This second load, which had thus been dried in the sun and open air, was now spread out in a loft and exposed to a further drying of the atmosphere for a little over six months.

The first charge of peppermint, which was distilled in the green state, weighed 2,332 pounds, and produced 6 pounds 9 ounces of essential oil, being 1 pound of oil for each 355·35 pounds of plants, or 0·2814 per cent. After the second load had been dried and exposed to the atmospheric action as stated for a little over six months, it was taken from the loft and distilled. I would say here that all the oil in the peppermint plant, as indeed in most, if not all, essential oil plants, is obtained from the leaves and blossoms. However, in distilling, the yield was more than 1 pound of essential oil for each 362·5 pounds of original green plants, which slight loss (about 2 per cent. in the amount of essential oil) is certainly to be accounted for by the portion of leaves and blossoms which rattled off in the rehandlings. The charge of peppermint, which was thus fully dried, had shrunk 49·4 per cent. of its original weight.

It will thus be seen that although the plants are very aromatic, both before and after cutting, there is no perceptible loss of the essential oil by the most thorough drying prior to distillation, the oil being so tightly sealed in its little prison cells that a force greater than that existing in the atmosphere or the rays of the sun is necessary to free it. Indeed, I have noticed that the leaves which fall from the plants in dry seasons and remain upon the ground over winter, even though subjected to rains and snows as well, are often found months afterward to be so strong that one would hardly suppose that any of the strength had passed off.* It is known, though, in practical experience, that when the plants are once dried and subjected to rains, the water carries off a portion of the oil, acting in that respect as a slight distilling force.

It is not within the scope of the present article to treat of the chemical effect produced upon the oil by the action of the atmosphere, the tests of the oil, etc. Such determinations may be found by consulting the papers referred to in the note in the previous column. The principal results of the experiment recorded herein may be summarized as follows:

First, in the treatment of peppermint and such other American essential oil plants as have been examined, no perceptible loss of essential oil by diffusion in the atmosphere is occasioned by a thorough drying of the plants prior to distillation in the open air at any ordinary temperatures.

Second, when the drying of the plants is continued for many months, a slight oxidation of the oil in the leaf occurs through contact with the oxygen in the air, decreasing its solubility and increasing its specific gravity, also raising its boiling point through the formation of a non-volatile and insoluble resinoid produced by oxidation.

Third, a long exposure of the plants to atmospheric action prior to distillation does not perceptibly affect the crystallizing tendency of the essential oil, nor other of its physical tests except those noted, as far as investigated.

Fourth, to obtain the best results, both as to the quality of essential oil and economy of transportation and manufacture, the plants should be dried as thoroughly as possible without endangering the loss of the leaves and blossoms in handling. Distillation should then take place as soon as convenient to prevent the oxidation of the oil in the leaf by atmospheric action.

* Read before the New York State Pharmaceutical Association in response to query. From an advance copy communicated by the author.

† During the past few years the consumption of peppermint has rapidly increased, so that statistics of production and distilleries now given show a marked increase over those given in my former papers on analogous subjects, which may be fonnd as follows: In the "Proceedings of the American Pharmaceutical Association" for 1886, page 121, and the *American Druggist* for September, 1886, page 161.—A. M. T.

* Since writing the above, I notice a paper by Mr. Joseph Schrenk in the *American Druggist* for June, 1888, which corroborates the determination given in the above paper. Speaking of the crystals in the leaves of plants which have been dried for fifty years, he says: "It is remarkable how long these crystals will remain in the dried leaves. Fragments from a herbarium specimen gathered in Europe in 1827 contain them in as perfect a condition as leaves of plants collected quite recently."—A. M. T.

YELLOW PRUSSIATE OF POTASH.

THE manufacture of this substance, although an industry of considerable importance, is comparatively little understood, either from a scientific or a practical point of view. At all events, many prussiate makers seem completely at sea with regard to the most favorable conditions for carrying on the manufacture, and there can be no doubt that in many cases great waste occurs through ignorance of the various reactions which take place during the process. The raw materials usually consist of carbonate of potash, iron filings or turnings, and organic matters containing carbon and nitrogen—such as dried blood, woolen rags, horn, hair, leather scraps, etc. The most suitable substances for use are, of course, those containing the largest proportion of nitrogen. The following are the percentages of nitrogen in various kinds of animal matter:

Horn	15 to 17
Dried blood	15 to 17
Woolen rags	10 to 16
Sheep shearings	16 to 17
Calves' hair	15 to 17
Bristles	9 to 10
Feathers	16 to 17
Hide clippings	4 to 5
Old shoes	6 to 7
Horn charcoal	2 to 7
Rag charcoal	2 to 12

Animal matters always contain more carbon than is necessary for the formation of cyanogen by combining with the nitrogen also present. Consequently, when such substances are heated with pearlash, the excess of carbon reduces a portion of the carbonate to the metallic state, and this potassium combines with the cyanogen to produce potassium cyanide. The manufacture of yellow prussiate of potash may be conveniently divided into three stages: (1) The production of the molten mass technically known as "metal," (2) the lixiviation, and (3) the crystallization.

(1) The "metal" is made by fusing animal matters with pearlash, almost invariably with the addition of iron scrap. The animal substances are sometimes used in their original condition, while sometimes they are previously charred. Generally speaking, however, a judicious mixture of the fresh and charred materials has been found to give the best results. The charcoal which is left on carbonizing animal matters contains a certain amount of nitrogen, decreasing in proportion as the temperature rises, but a smaller quantity of charcoal is also thereby produced. For example: 100 parts of rags carbonized at a certain temperature left 75 parts charcoal containing 12 per cent. of nitrogen, while the same rag carbonized at a higher temperature yielded 25 parts of charcoal, which contained only 2 per cent. of nitrogen. The animal matters employed should not leave much ash on ignition, as this would both thicken the mass and decompose a portion of the potash. In this respect sand is specially objectionable, for on ignition 1 part will decompose 2 of pearlash, owing to formation of silicate of potash. It is not necessary that the pearlash should be quite pure, in fact, a certain proportion of sulphate is stated to be useful, as it is changed into sulphide by ignition with the carbonaceous materials. The theory of the formation of yellow prussiate of potash may be briefly stated as follows: The carbonate and sulphate of potash react with the carbon, nitrogen, and iron, forming in the first instance sulphide of potassium, which afterward converts the iron into sulphide, while potassium cyanide is simultaneously produced. It should be here explained that ferrocyanide of potassium (yellow prussiate) is not formed during the ignition of the above mentioned materials, but results from the lixiviation of the fused mass with water, when the cyanide of potassium and iron sulphide decompose each other, producing ferrocyanide and sulphide of potassium. It is quite obvious that even if any ferrocyanide were produced during the process of fusion, it would almost immediately be decomposed, at the intense heat to which the mass is subjected, into potassium cyanide, iron carbide, and nitrogen gas. If any doubt were felt on this point, the experiments of Liebig conclusively prove that the formation of ferrocyanide takes place on dissolving the ignited mass in water, but not previously.

Liebig found that if the fused mixture be allowed to cool and then treated with moderately strong alcohol, potassium cyanide alone is extracted, and the residue, when dissolved in water, no longer yields ferrocyanide. As ferrocyanide is not formed during the process of fusion, the presence of iron in the preliminary stages may appear superfluous, but such is not the case. The presence of iron is necessary for two reasons, first, because the sulphate of potash which is generally present is converted into sulphide and bisulphide, and these, in the absence of iron, would decompose some of the cyanide of potash into sulphocyanate, thereby causing a loss of cyanogen so far as yellow prussiate is concerned; and, secondly, because potassium bisulphide has a very corrosive action on the iron pot in which the fusion takes place. When iron is present, it readily decomposes any alkaline sulphides, thereby preventing formation of sulphocyanate, and being itself converted into iron sulphide, which is again changed into prussiate by the action of the aqueous cyanide.

Pear-shaped iron pots were formerly used for fusing the raw materials. The arrangement now generally adopted in large English works consists of a series of iron pots almost hemispherical in shape, set in brickwork, and each heated by a separate fire and circular flue. These vessels are closed by iron lids, with apertures for the admittance of animal matters, the aperture being at once closed by a slide after each addition. Through every lid there passes a vertical spindle, carrying a set of blades for mixing the materials, and set in motion by a suitable shaft worked by steam power. Instead of the ordinary iron pots, reverberatory furnaces are often employed, especially in Germany. The reason for this preference is that ordinary iron vessels are worn out in a comparatively short time, the destructive action being greatest on the under surface of the muffle. A much larger quantity of raw material can also be operated upon at one time if a reverberatory furnace be used. The mode of procedure depends to some extent upon the condition of the organic materials employed. If fresh, the muffle or furnace must be left open, so as to permit the mixture to be well and frequently stirred, and additions to be made at intervals until eventually ammonia ceases to be evolved. The furnaces are arranged in such a manner that when the carbonate of potash has once become fused the doors of the fireplace may be shut, and no fresh firing is required during the introduction of the animal matters. The molten mass is kept well stirred by means of a thick iron bar, suspended by a chain, and fixed in an aperture in the side of the furnace. By the use of this arrangement the stirring is much more easily and thoroughly effected than is the case with the old fashioned pots.

Ordinary reverberatory furnaces cannot be used for the fusion, because the silica in the hearth would combine with the potash to form silicate of potash. Gas generators with air blast are now sometimes employed instead of ordinary fuel in the manufacture of yellow prussiate of potash. Several advantages are gained by operating in this manner, especially that of permitting the regulation of temperature and the admission of oxygen, so as to obtain an ordinary, a neutral, or a reducing flame, according to requirements. In the preparation of the "metal," for every 100 parts of pearlash from 100 to 125 parts of fresh animal substances are required, together with 6 or 8 parts of iron in some form or other. The pearlash, or a mixture of 1 part of pearlash with 2 to 4 parts "blue salt" or "blue potash" (this substance will be referred to later on), is melted in the furnace and heated to bright redness, so that the temperature of the mass may not be reduced too much by the addition of the animal matters. These, in their original condition, or an equivalent quantity of carbonized materials, together with the proper proportion of iron, are then introduced—first pretty frequently, afterward at longer intervals. Each addition of animal matter causes a somewhat violent frothing and escape of combustible gases, along with water and carbonic acid, and the whole becomes thick—not so much owing to the introduction of solid substances as by the fall of temperature, resulting from the production of such large quantities of gas. In order to hasten the decomposition, vigorous stirring must be applied. When the reaction is at an end, the

semi-fluid mass is transferred to cast iron dishes, and the furnace again filled with carbonate of potash and heated. In this way four or five charges may be accomplished every day, and the process carried on almost continuously.

The most favorable conditions for effecting the melting part of the process are attained when the heat approaches whiteness, and a bright, clear flame is produced as soon as the raw materials are introduced. According to one authority, woolen rags and good pearlash, with a small proportion of waste iron, have produced the largest yield of yellow prussiate, although even in this case two-thirds of the total nitrogen present was lost in the form of ammonia.

(2) *Lixiviation.*—The fused mass, if properly prepared, should yield about 16 per cent. of prussiate on dissolving in water. In this part of the process, the "metal" when cold is broken into lumps and placed in cold water mixed with the weak lyes from former operations. Heat is then applied, until the temperature rises to about 180° or 190° F., and the liquid stirred vigorously so as to promote rapid solution, because some of the potassium cyanide is apt to be decomposed during lixiviation. When the solution attains a density of from 30° to 40° Tw. it is left to clarify, the heat being withdrawn. The clear solution is decanted, and evaporated in pans which are generally heated by the waste heat of the furnaces. When it has a density of 54° Tw. it is run off into the crystallizers, where it deposits the crude salt.

(3) *Crystallization.*—This is a very important stage of the manufacture, as it is the final process by which the crude prussiate is rendered sufficiently pure to be placed on the market. The impure substance is dissolved in warm water until the solution stands at 54° Tw., and after all insoluble matter has deposited, the clear liquor is placed in the crystallizing vessels. These are occasionally made of wood, but when such vessels are used the crystallized salt generally possesses a green color, which is believed to be due to the tannin present in the wood. On this account cast iron crystallizers are more frequently employed. The crystallization proceeds slowly—often going on for several weeks in large vessels. The mother liquor is then drawn off, and, if not too impure, is used for dissolving fresh quantities of the crude prussiate. The ferrocyanide is deposited in crusts in the crystallizers, but by hanging lumps of the solid salt in the solution long clusters of crystals may be obtained, and by suspending these in fresh prussiate lyes immense crystals are produced. From 100 parts crude prussiate about 90 parts pure potassium ferrocyanide are obtained, or sometimes in the case of purer materials 97 parts.

Sulphate of potash is often present in commercial yellow prussiate. The separation of this impurity is best effected on the large scale by evaporating the prussiate solution to a density of 62° Tw., at which point most of the sulphate will crystallize out. If the clear liquor be then drawn off, diluted to 52° Tw., and allowed to cool, almost pure potassium ferrocyanide will gradually deposit. This may be rendered absolutely pure by gently fusing the crystals, dissolving in water, and treating with a small quantity of acetic acid, which will decompose any carbonates and cyanides. On adding sufficient strong alcohol the ferrocyanide is precipitated, and when crystallized once or twice more from water it may be regarded as chemically pure.

Blue Salt.—This substance, to which we have previously referred, is a residue obtained in the manufacture of prussiate of potash. The last mother liquor contains a large quantity of carbonate of potash, along with smaller amounts of hydrate, silicate, chloride, and sulphocyanate. It is concentrated until the liquid has a density of 90° Tw., when most of the chloride, silicate, etc., separates out, and the strong liquor containing the greater proportion of the carbonate is evaporated to dryness, and calcined in a reverberatory furnace. The dry residue constitutes the "blue salt" or "blue potash," and contains from 70 to 80 per cent. carbonate of potash. It may be employed instead of pearlash, or mixed with it for the next batch of yellow prussiate. The composition and amount of the insoluble residue left on lixiviation of the "metal" vary according to the proportions and character of the raw materials used. Other conditions being equal, horn gives the lowest percentage of insoluble matter on lixiviation.

The large proportions of potash and phosphates contained in the insoluble residues render them well suited for use in the manufacture of artificial manures. As already mentioned, when regarded from a scientific or economical point of view, the yellow prussiate industry is carried on under very imperfect conditions. In addition to the amount of potash, there is a very considerable waste of nitrogen, first, because the larger proportion of that element present in the animal substances is not converted into cyanogen at all, but passes off chiefly in the form of ammonia salts; and, secondly, because part of the potassium cyanide which is actually produced is lost by decomposition, and another portion is left in the mother liquor. It has been calculated that out of every 100 parts of ferrocyanide which should theoretically be obtained, 4 parts are lost when fairly pure materials have been employed, and 14 in the case of impure ingredients.

The following analyses indicate the percentage composition of two samples of insoluble residue:

	No. 1.	No. 2.
Sulphate of potash, etc	9·03	3·21
Phosphates of lime, magnesia, and iron	13·74	6·24
Oxide of iron	13·34	19·58
Lime and magnesia	5·08	7·23
Sand and silica	23·97	29·24
Charcoal and moisture	34·81	34·50
	100·00	100·00

According to Karmrodt, the following proportions of the nitrogen contained in various animal substances are actually converted into cyanogen during the manufacture of yellow prussiate of potash:

	Per cent.
Woolen rags	16
Horn	20
Leather cuttings	33
Cow hair	14
Dried blood	16
Horn charcoal	56
Rag charcoal	33

As is well known, human excreta contains a considerable proportion of nitrogen, and there seems no reason why this should not be employed in the manufacture of yellow prussiate. It is quite possible that municipal bodies might find this a convenient and profitable plan of disposing of a portion of the sewage with which they have to deal. It is obvious to all persons who have given this subject much consideration, that the nitrogen required in the manufacture of yellow prussiate of potash might be obtained with comparative ease from the surrounding atmosphere. Indeed, from a theoretical point of view, this seems a charming process. About fifty years ago the Society of Arts awarded Mr. Lewis Thompson a medal in connection with this very process. Mr. Thompson ignited a mixture of 2 parts pearlash, 2 parts coke, and 1 part iron turnings in an open crucible for a considerable time at a full red heat. The resulting black mass was found to contain a large quantity of ferrocyanide, together with excess of carbonate of potash, etc. This process, or a similar one, in which a current of air was passed over a mixture of charcoal and iron saturated with carbonate of potash, was tried on a large scale for two years at Mr. Bramwell's works, at Newcastle. About one ton of yellow prussiate was made daily by this process, but it was not found to work profitably, and was eventually abandoned, chiefly, it is said, owing to the large amount of fuel required, and because the cylinders, whether of iron or fire clay, were not able to stand for any length of time the intense heat to which they were subjected.—*Industries.*

MICROSCOPICAL MEASUREMENTS.

TABLE showing the variation in measurements due to the different applications of light and illuminations.

The image of $\frac{1}{10}$ inch was the object on which these measurements were made, and was ruled on a glass disk of No. 2 covering glass, $\frac{1}{1000}$ inch in thickness.

All measurements were taken on one and the same ruling, with the same microscope, objective, and eye piece, under the same focus and having the microscope in the same position continually, and only changing the mirror and excluding the one light while the other was used.

UNMOUNTED.

Lamp Light.

Lines Downward.

Concave mirror	$\frac{1}{10}$ in.	$\frac{12}{100000}$ −
Plane mirror	$\frac{1}{10}$ in.	$\frac{5}{100000}$ +
Illuminated through objective	$\frac{1}{10}$ in.	$\frac{8}{100000}$ +

Lines Upward.

Concave mirror	$\frac{1}{10}$ in.	$\frac{12}{100000}$ +
Plane mirror	$\frac{1}{10}$ in.	$\frac{14}{100000}$ +
Illuminated through objective	$\frac{1}{10}$ in.	$\frac{14}{100000}$ +

MOUNTED ON GLASS.

Lamp Light.

Concave mirror	$\frac{1}{10}$ in.	0
Plane mirror	$\frac{1}{10}$ in.	$\frac{11}{100000}$ +
Illuminated through objective	$\frac{1}{10}$ in.	$\frac{11}{100000}$ +

Day Light.

Concave mirror	$\frac{1}{10}$ in.	$\frac{10}{100000}$ +
Plane mirror	$\frac{1}{10}$ in.	$\frac{10}{100000}$ +

A number of comparisons were made at each position and in the same temperature.

A Spencer objective was used for these measurements. But Bausch & Lomb and Gundlach objectives were also tried, obtaining the same results.

The microscope used is one constructed on my late patents, and has a micrometer for measuring similar to a cobweb micrometer. But instead of cobwebs, three movable steel pointers are used, which are worked as fine as this metal will permit. The stage is mechanical, and the main slide is moved with great precision by a fine screw 100 threads per inch.

CHARLES FASOLDT, SR.

Albany, N. Y., July, 1888.

THE PHOTOMETRY OF COLOR.

AT the last meeting of the Physical Society, London, Captain Abney read a paper as above.

The author referred to a paper read before the society in June, 1885, in which he described a method of producing a patch of monochromatic light, or a mixture of colors on a screen, and in the following year General Festing described a method of comparing the luminosities of colored with that of white light. The method described in the former paper was used for obtaining curves of illumination with light of different colors, and also for some investigations in color blindness. It was found that about 50 per cent. of the persons experimented on were deficient to a greater or less extent in the perception of red. The author stated that as he had never found any one who was able to perceive a greater portion of the red end of the spectrum than General Festing and himself, and as their color vision in this respect was identical, he had taken their own vision as the normal standard with which to compare the vision of others.

The author, in conjunction with Mr. Russell, had recently been making some investigations in the fading of water colors, and for this purpose required to determine with exactness shades of color, as well as the amount of fading in absolute measure. As the old method depended on the vision of the observer, it required that all the observations should be made by the same person, which was inconvenient.

The author had had occasion to make a number of determinations of the amount of white present in various tints of gray. The method which he devised for this purpose consisted in placing a patch of the tint to be observed and a white patch side by side. They were then both illuminated by a beam of white light, a rod was placed in front of the patches to cast a shadow, and the light falling on the white patch was gradually diminished by means of a rotating sector, the angular aperture of which was varied until a balance was obtained. The proportion of white present in the gray patch was then known at once from the angular aperture of the sector. In order to exclude external light, the patches were placed inside a photometer box, and observed through an aperture in the side. In order to adapt this method to the comparison of the amount of light from different portions of the spectrum which was reflected from patches of different colors, the standard of comparison being the amount reflected from a white patch, it was necessary to obtain two identical spectra with sufficient azimuth to give two shadows. A split lens was originally used for this purpose, but the method had the disadvantage that the half of the spectrum which passed through the base of the prism was not so luminous in the red as the other half. A double image prism behind the collimator was therefore used, giving two similar spectra, one above the other. In order to get sufficient azimuth, the author used two prisms at right angles, and by this means a shadow was obtained both on the white and on the colored surface.

The equality of the two beams was ascertained in the first place by the use of a second white patch in place of the colored one. To make an observation, the aperture of the revolving sector, which intercepted part of the light falling on the white surface, was adjusted so that equally intense shadows were obtained on both patches, when these were illuminated by light from a given portion of the spectrum. A series of luminosity curves were then drawn, giving the intensity of light from a given portion of the spectrum reflected from the colored surface, relatively to the intensity of light from the same portion of the spectrum reflected from the white patch. This method gives a means of standardizing colors, as by it any given color can be reproduced on the screen quite independently of whether the vision of the observer be normal or otherwise. For this purpose a color templet is made consisting of a cardboard disk, out of which is cut an opening of a definite size and shape, the contour of the opening being determined by the conditions that, when the center of the disk is placed at a fixed point of the spectrum, and the disk is turned until the whole of the aperture is opposite some portion of the spectrum, the aperture allows rays from the different parts of the spectrum to pass in the same proportion as the light reflected from these parts by a patch of the given color; and the angular aperture for each part of the spectrum is in the same ratio to 360° as the amount of light from that part reflected by a patch of the given color to the amount of light from the same part reflected by a white patch. The center of the disk remaining fixed at the same point as before, the disk is rotated at a rapid rate in front of the spectrum, and the light passing through it and falling on a white screen, will clearly give the required color on the screen.

A number of experiments made by the method on the relative quantities of different colors which had to be mixed in order to produce gray, gave results in very close agreement with those obtained by the author's former method. A disk having its area divided by three radii into three portions colored red, blue, and green will, when rotated, appear gray to a person of normal vision. A color-blind person will see gray with certain proportions of blue and green only, and the addition of red will, in his sight, be equivalent to adding a good deal of black and a small proportion of green.

The president (Professor Reinold) inquired whether the relative intensities in different parts of the spectrum were the same for light from different sources.

Professor S. P. Thompson pointed out that the author had not given any definition of white light. He thought that owing to the difference in thickness of different parts of the prism there would be a difference of luminosity, the amount of which would depend on the material of the prism, and he asked how the results could be made comparable in the case of different prisms. Nothing hitherto done in the photometry of color approached the author's method in accuracy.

Captain Abney, in reply, stated that he had usually employed an arc lamp as the source of light, but he had not found any such difference as the president mentioned when other sources of light were used. The templet, when rotated in front of any spectrum, always gave light of the same hue. With regard to absorption, Professor Thompson's criticism was well founded, and he had used an arrangement by which the white light passed through the same prism under exactly the same circumstances as the other light, so that the absorption was the same in each case. In the course of the paper, he had mentioned that he had found that the light of the sky was green—a statement at which the president expressed some surprise. The author pointed out that not only was the fact generally known to artists, but it was in accordance with Lord Rayleigh's theoretical conclusions.

EFFECTS OF FOOD PRESERVATIVES ON THE ACTION OF DIASTASE PANCREATIC EXTRACT AND PEPSIN.

By HENRY LEFFMANN, M.D., and WILLIAM BEAM, M.A.

THE use of antiseptics in perishable articles of food has become quite general in recent years, and has been, to a certain extent, the subject of legislation. Salicylic acid has been probably the most used, and while the sanitary authorities in different countries have, as a rule, opposed its use, there has been no positive evidence of its injurious action, even when continued for some time. Lehmann published in Pettenkofer's "Archives of Hygiene" several instances in which healthy male adults had taken for many days considerable doses of this acid without apparent injury. While there may be a legitimate field for the use of these agents in articles of food of a highly perishable character, and especially where the addition is made known, there can be no question that their indiscriminate use is dangerous. Independently, however, of any directly injurious action, it is important to inquire how far they may interfere with the nutritive or medicinal value of any articles with which they may be associated. The matter has been brought prominently to our notice in consequence of some analyses made by us, in which the free use of salicylic acid in beers and malt extracts was detected. Similar results in regard to beers were found by various State boards of health and by the Department of Agriculture of the U. S. government. It becomes important, then, to inquire how far the presence of the substances may interfere with the diastasic action ascribed to preparations of malt. It must be noted that with a number of the malt extracts now on the market the addition of a preservative has very little significance, because, as prepared, these articles are merely weak beers and possess

no diastasic power. Thus, of eleven samples tested, including all the extracts widely known in this market, only four had any appreciable effect on starch, and but one of these was strikingly efficient. We have undertaken a few experiments to determine what retarding effect such preservatives may possess. The method of operation was that indicated by Drs. Duggan and Coale, in papers in the *American Chemical Journal* and elsewhere, based on the estimation of the sugar formed in presence of a large excess of starch. Arrowroot starch was selected for reasons given by these observers. To avoid error due to the varying action of the dilute solutions of malt which are required for the experiments, a blank experiment was made in each set, and from this the diastasic value of the pure malt extract was determined. In the first observations maltine was employed, that having been shown by our previous tests to be by far the most active of the commercial extracts, but later Schuchardt's diastase was used. The Fehling's solution was prepared as directed by Allen, and the determinations made volumetrically. Many of the experiments were duplicated, with accordant results.

In addition, a number of tests were made by the method given by Allen for valuing malt extracts. The results obtained were similar to those given below, but not being capable of quantitative comparison, are not detailed here.

The antiseptics selected were salicylic acid, boric acid, sodium acid sulphite, saccharin, beta-naphthol, and alcohol. The sample of beta-naphthol was of the form now sold under the name hydro-naphthol.

In all the experiments the temperature, time of action, and strength of starch solution [30 grms. to the liter] were the same.

In the following experiments, 0·5 c. c. of maltine diluted to 50 c. c. was added to 100 c. c. of starch solution. The figures give the proportion of antiseptic to the whole volume of solution and the amount of sugar formed from the starch, that contained in the maltine being deducted.

EXPERIMENTS WITH MALTINE.

Antiseptic Used.	Amount.	Fehling's Solution Required.
None,		245 c. c.
Salicylic acid,	1 to 500,	No sugar formed.
" "	1 to 1,000,	" "
" "	1 to 20,000,	245 c.c.
Boric acid,	1 to 1,000	245 c.c.
Sodium acid sulphite,	1 to 1,000,	245 c.c.
Saccharin,	1 to 1,000,	18·5 c.c.
"	1 to 500,	5·6 c.c.
Beta-naphthol,	1 to 1,000,	204 c.c.
"	1 to 500,	174 c.c.
Alcohol,	1 to 25,	245 c.c.

In the above experiments the antiseptics were added to the starch and the maltine allowed to act at once. In the following, very small quantities of salicylic acid and alcohol were first mixed with the maltine and allowed to stand four days before addition to the starch.

Antiseptic Used.	Amount.	Fehling's Solution Required.
Salicylic acid,	1 to 20,000	174 c.c.
Alcohol,	1 to 500,	221 c.c.
Salicylic acid,	1 to 20,000, }	174 c.c.
Alcohol,	1 to 500, }	

As before, the proportion is given to the whole volume of liquid after addition of the starch.

EXPERIMENTS WITH DIASTASE.

One part of diastase to five hundred of liquid.

Antiseptic.	Amount Used.	Fehling's Solution Required.
None,		300·5 c.c.
Salicylic acid,	1 to 3,000,	286 c.c.
" "	1 to 1,500,	16 c.c.
" "	1 to 1,000,	No sugar.
Saccharin,	1 to 1,000,	86·3 c.c.

One part of diastase to one thousand of liquid.

None,		263 c.c.
Salicylic acid,	1 to 1,000,	No sugar.
Boric acid,	1 to 1,000,	250 c.c.
Sod. acid sulphite,	1 to 1,000,	263 c.c.
Saccharin,	1 to 1,000,	No sugar.
Beta-naphthol,	1 to 1,000,	238 c.c.
Alcohol,	1 to 25,	250 c.c.

One part of diastase to two thousand of liquid.

None,		238 c.c.
Salicylic acid,	1 to 5,000,	82 c.c.
" "	1 to 3,000,	No sugar.

EXPERIMENTS WITH FAIRCHILD'S PANCREATIC EXTRACT.

Each test was made with 0·2 grm. of extract.

Antiseptic.	Amount.	Fehling's Solution Required.
None,		78 c.c.
Salicylic acid,	1 to 1,000,	No sugar formed.
Saccharin,	1 to 1,000,	" "
Beta-naphthol,	1 to 1,000,	78 c.c.
Boric acid,	1 to 1,000,	78 c.c.
Sod. acid sulphite,	1 to 1,000,	80 c.c.

EXPERIMENTS ON PEPTIC DIGESTION.

In these, saccharated pepsin, U. S. P. was employed, together with hydrochloric acid, the vessels being maintained for about five hours at 105° F. The proportion of each antiseptic was one part to 1,000 parts of liquid.

Sodium acid sulphite and boric acid were without effect.

Saccharin and salicylic acid had a slightly retarding action.

Beta-naphthol almost entirely prevented the action. These experiments were repeated, with precisely the same result.

With pancreatic extract digesting albumen the results were practically the same, but the retarding action of the salicylic acid and saccharin was not quite so marked. The solutions from the pancreatic experiments were allowed to stand for forty-eight hours. Putrefactive change had occurred in all but that containing the beta-naphthol, in which no putrefactive odor could be detected, even after a period of three weeks. Of the other solutions, that containing sali ylic acid was the least advanced in putrefaction.

From the above experiments it will be seen that salicylic acid prevents the conversion of starch into sugar under the influence of either diastase or pancreatic extract, but does not very seriously interfere with peptic or pancreatic digestion of albumen.

Saccharin holds about the same relation as salicylic acid.

Sodium acid sulphite and boric acid are practically without retarding effect.

Beta-naphthol interferes decidedly with the formation of sugar by diastase, but not with action of pancreatic extract on starch. Peptic and pancreatic digestions of albuminoids were almost prevented by this agent.

It is obvious, then, that the indiscriminate use of these agents in the preservation of food is to be regarded as objectionable and a proper subject of sanitary supervision. Their use is scarcely allowable under any circumstances, and certainly only when the nature of the preservative and the amount is distinctly stated. These remarks apply more particularly to salicylic acid, saccharin, and beta-naphthol, but the use of boric acid and sodium acid sulphite may be brought also under the same restrictions, because their actions on the animal functions are not yet thoroughly investigated.

NORFOLK ISLAND AND ITS RESOURCES.

By Isaac Robinson, U. S. Consul.

Norfolk Island is situated in the southwestern Pacific, in (pier) 29° 3' 45" south latitude and 167° 58' 6" east longitude, 980 miles ENE. from Sydney, New South Wales, and about midway between the north cape of New Zealand and the French island of New Caledonia, distant about 380 miles from either point; its dimensions are about 5 miles long by 3 miles wide, with a total area of 8,600 acres. Just outside the limits of the tropics, the extremes of temperature are never reached, the climate being most equable, the thermometer at no time ranging higher than 84 degrees in summer and never lower than 46 degrees in winter. Discovered by the celebrated navigator Cook in one of his early voyages (1774), and described as densely wooded to the water's edge, the island now presents a very different appearance indeed, open, park-like downs interspersed by stately groups of the handsome and indigenous pine (*Arancaria excelsa*) meeting the eye in every direction, Mount Pitt (1,028 feet), with its connecting range, and the low-lying adjacent lands to the northwest being the only wooded parts of any consequence.

Originally settled by Phillip Gidley King, a lieutenant in King George's navy, in 1788, by a mixed party of convicts and free persons, they lost their vessel, the Supply, on the south reef, and after surmounting innumerable difficulties and hardships, formed themselves into a very happy and contented community. But there were breakers ahead. Surrounded, as the island is, except in a few places, by a barrier of perpendicular rocks, abrupt precipices marking almost the entire coast line, it is, as a matter of course, most difficult of access; permeated, besides, by its dreary isolation and monotony, it was peculiarly adapted for the purpose that the English government had in view, viz., a convict settlement. So, therefore, in 1809, orders were issued to break up the little colony and deport it to Tasmania, which arrangement, much against the wish of many of the colonists, was carried out.

From that time forward, with but little intermission until 1856, the island was used as a convict settlement of the worst type, where irreclaimable prisoners weeded out from the jail yards of Tasmania and New South Wales were sent, and the place became, as was aptly described by a distinguished botanist visitor, "a hell within a paradise." About the year last mentioned, and early in the fifties, it was understood that the English government had it in contemplation to abandon the settlement, the results not being such as to justify the expense; consequent on this intimation, the many influential friends in England of the Pitcairn Islanders (descendants of the well known Bounty mutineers), who, it was stated, were getting overcrowded in their present abode, made strong representation to the government to have the island handed over to them, as it was thought that the climate, surroundings, and isolation would be most suitable and just the thing. The request was favorably considered by the then government, and not long after her Majesty, by an "order in council," transferred the island, with all its numerous buildings, implements, and stock, over to this interesting people, descendants really of those unruly men who, in 1788, defied her grandsire's authority and turned his captain adrift on the open sea—a noble revenge, indeed. The arrangements for transshipment were soon made, and a few months later a ship appeared at Pitcairn, and the whole community, every soul, ninety-five all told, bag and baggage, with their magistrates, chaplain, laws, peculiarities, embarked in the Morayshire and sailed for their new home, 3,000 miles away, arriving at Norfolk Island on June 8, 1856, and thus began the present occupation; all that remained of the convict element, every human being, being taken away in the same vessel. A year later, however, a few who were discontented, one or two families, and a few years later again some three or four more, deserted and found their way back to the old home, these few forming the nucleus of the present community there. Kington, the town, is on the south side, and was the center of operations during the old regime, and is also now the principal mart for trade.

Most of the old private houses are occupied, but the public buildings, with the exception of the commissariat store and the two soldiers' barracks, are in ruins, the inhabitants, which are fast increasing, being scattered all over the island in neat wooden tenements built by themselves. Immediately confronting the town are two small islands or islets, Phillip and Nepean, which afford some little shelter to the pier, which is situated on this side and is indeed the principal landing place; here most of the business of the island is effected, but on the north side there is also a good landing place, used when the wind is south or southward and the pier unapproachable. There is, however, anchorage at both places when the wind is off shore, but that on the south is in bad odor on account of the rocky or foul bottom, while the north side, where the seas appear to be calmer and the holding ground better, is in much more repute with mariners. All the traffic has to be done with whale boats, which are marvelously well handled by the islanders, who often work in waters that would daunt the ordinary boatman, managing their craft with wonderful skill and dexterity. The signals for landing are few and simple—ensign, good landing; a dark flag over ensign or red flag, go to cascade; dark flag alone, no landing either side.

The soil is exceedingly fertile, composed, as it is, of a dark chocolate loam, or decomposed basalt, and will grow almost any sub-tropical production, besides those of a colder latitude, the temperate climate and the absence of frost being particularly adapted to almost any growth; sweet and Irish potatoes, yams, arrowroot, bananas, coffee, sugar cane, maize, oranges, lemons, apples, rose apples, lognats, date plum, mango, cheromoyer, peach, etc., thrive equally well and give good results. The native vegetation is almost wholly peculiar, and includes the before mentioned conifer, *Araucaria excelsa*, a palm (*Areca baneri*), and a tree fern (*Alsophila excelsa*), all of which are stated to be the handsomest of their tribes, and are in much repute with neighboring nurserymen; there are besides upward of thirty different kinds of ferns. The native woods also are good, and some of them very durable, and are largely used for fencing and domestic purposes.

Only about 400 of the nearly 4,000 acres already alienated are under cultivation, the rest, being well grassed in places, are grazed over by the sheep, cattle, and horses that roam at will over the uninclosed waste lands. There is, however, a deadly pest in three plants which appear to be steadily advancing, notwithstanding a portion of every year is set apart for their destruction. The plants or weeds alluded to are two solanums (*sodomaeum* and *auriculatum*) and *Cassia lavigata*. The community gain a subsistence by whaling and agriculture principally.

The men are expert whalemen, and are in much repute in our whale ships that cruise in these seas, and in the season when the whales, the humpback, come about, from July to October, inclusive, follow the occupation with assiduity and celerity, the business being most congenial to their habits, which are very "watery." Ordinarily about seven boats are manned, which, in fine weather, every day are launched and with varying success cruise around the island. The average "take" is about 50 tons, which is usually sold on the spot, £22 per ton being the price obtained for last season's oil; a price, considering the heavy working expenses, that leaves little margin to the whalemen. All, however, do not depend on this business alone for a livelihood, some few devoting their attention solely to farming, but the occupations are generally mixed, the whalers cultivating their farms in bad weather, but as a matter of fact nearly everything depends on the success of the fishery. The staple crops of the cottage farms are Irish and sweet potatoes, maize, bananas, and culinary vegetables, which find a ready sale on our whalers, which periodically call for recruits and fresh meat, the trade being carried on by barter, United States cloths and denims being in good repute here; indeed, all the boats and gear of the island bear the New Bedford stamp; the men would not look at any other. The government of the island by powers granted by her Majesty is home rule, pure and simple, and is vested in three officials, chief magistrate and two councilors, who are elected annually by the people, the chief magistrate being responsible, and the medium of communication with the higher officials. The three magistrates act under commissions bearing the great seal of the colony, issued by the governor of New South Wales, who himself holds a separate authority as governor of Norfolk Island. The governor has, in fact, unlimited power, but holds a very mild sway, allowing the islanders to do very much as they like, so long as they do not go too far.

The laws are few and primitive, and could be printed on two sheets of foolscap; nevertheless, they answer the purpose well, there being no crime to speak of, nor any lock-up or need of one. There is no revenue except a few waifs and strays in the shape of small fines, etc., which seldom amount to much, but is responsible for the signal master's salary of £1 10 ($7.50) per annum, besides a court sweeper at £1 ($5). The chief magistrate's salary is £25, but up to last year it was only £12; this, with the emoluments paid to the colonial surgeon, chaplain, registrar, and postmaster, is paid out of the interest of a fund in Sydney which has been accumulating for some years, and began with the sale of 1,000 acres of land to the Melanesian mission. The land tenure—the whole island is subdivided into 50 acre lots—is held in what, in forensic parlance, is called peppercorn grants; the original immigrants from Pitcairn received 50 acres apiece; that is, the elders or heads of families, and likewise for some years after each couple when they married got the same concession.

Early in the seventies, however, this was changed, young married couples only getting 25 acres, until in 1884, when the then governor, Lord A. Loftus, visited the island, he refused peremptorily to issue any more grants, on the plea that what was already given was not utilized anything like what it ought to be, and ever since the land question has been a vexing and exercising topic; this, together with annexation to New South Wales, first mooted by the English authorities about eighteen months ago, and strenuously, to a man, opposed by the islanders, has of late caused much anxiety to the more thinking portion of the community.

The imports include clothing, groceries, agricultural implements, and timber for building purposes; the exports, oil, wool (output generally 14 to 17 bales), horses, sweet and Irish potatoes, onions, bananas, and sometimes sheep. The oil and wool go either to Auckland or Sydney, the latter port taking besides sweet potatoes and bananas, but for other produce, such as horses, onions, Irish potatoes, etc., Noumea, at present, is the only market open to us, and so far with good results. The importation of liquor, except for medical purposes, is absolutely prohibited; the law is strict, and the people care little for it; there are no duties, and consequently no custom house or any other record kept, but the imports and exports together in a favorable year would probably amount to £6,000. Our communications at one time were very erratic, but now and for some time past a great improvement has taken place. From Auckland comes a trading schooner four or five times, and the mission vessel twice (March and July) a

year, and the New South Wales government gives a small subsidy to a Fiji trading steamer to make quarterly calls.

Formerly all letters, etc., converged at Auckland and were sent as opportunity offered, but now since the new arrangement at Sydney any mail matter that finds its way there is stopped and sent on by the steamer. The population of the island on December 31, according to the registrar's returns, was 741 all told, viz.: Norfolk Island community, 248 males, 276 females=524; Melanesian mission, 169 males, 48 females=217. The return particularizes them as follows: Norfolk community, married couples, 78; widows and widowers, 9 and 10 respectively; above the age of fourteen, 78 males and 66 females; under that age, 114 males and 128 females; strangers, 4 males and 3 females; absent from the island, 36 males and 8 females; Melanesian mission, whites, 14 males and 8 females; blacks, 158 males and 43 females; absent from the island, 3 males and 3 females—white.

The stock returns for the past year are not yet made out; but 2,000 sheep, 1,200 cattle, and 350 horses, although perhaps rather underestimated, is near about correct.

The sanitary condition of the island is good, the death rate exceeding low, averaging 9 per 1,000. There is usually little sickness and an entire freedom from malarial fevers of all kinds. The climate is salubrious generally, but at times during the prevalence of N. and NE. winds it is relaxing, but these winds seldom prevail.

The great "Melanesian Mission," of the Church of England, has its headquarters here and is worked by a bishop, the well known Dr. Selwyn, titular bishop of Melanesia, assisted by a numerous staff of clergymen, mechanics, etc., and has all the appliances at hand for carrying on a large establishment. The first bishop, the lamented Dr. Patterson, who it will probably be remembered was murdered at Santa Cruz some years ago, established, with the consent of the settlers, in 1866, his quarters here, purchasing from Governor Young 1,000 acres of land for the purpose. The mission has numerous stations at the many islands forming the Hebrides, Bomks, and Soloman groups. The principal object is besides the civilizing process immediately carried on, to capture young men at savage islands and bring them, if suitable, to headquarters and educate them for teachers, much good having already, it is stated, been done in this fashion. Connected and owned by the mission authorities is a handsome auxiliary barquentine, the Southern Cross, which, carrying the blue ensign and the olive branch, makes three voyages a year between the headquarters and its many stations, finishing the last trip about the middle of November, when she goes on to Auckland to refit and lay up during the three hurricane months; a midwinter trip is made to Auckland in June to recruit supplies. The station itself is quite isolated from the other community, and stands in its own grounds distant some three miles to the NW. of the town. It may be added that the institution in the course of the year is the means of diffusing a not inconsiderable sum of money among the other settlers, for boating and sundries.—*Norfolk Island, April* 16, 1888.

GEOLOGY.

By ARCHIBALD GEIKIE, LL.D., F.R.S.

INTRODUCTORY.

AN ordinary dwelling house, such as those in which most of us live, is built of various materials, and one of these is always stone. In the walls, the hearths, the chimney pieces, and the roofs, stone is used. But in each of these cases the kind of stone usually differs from that employed in the rest of the building. Thus the walls may be made of freestone, or limestone, or brick, the hearths of flagstone, the roofs of slate or tiles, the chimney pieces of marble, while still another sort of stone called coal is burnt in the fireplaces. Go out into the streets, and you find a still greater diversity. The causeway stones are of one kind, those of the foot pavement of another. Many different ornamental varieties are made use of in the shops and buildings. So that merely by looking at houses and streets you may readily perceive that there are many different kinds of stone.

If you examine them a little more narrowly, you will see that they receive various treatment before they become part of a building. The stones of the walls have been chipped and dressed with chisels and hammers; the marble of the chimney pieces has been smoothed and polished; the slates have been split into thin plates. But some of these building materials have undergone much greater changes. The bricks, for instance, were originally soft clay which has been hardened by being baked in ovens. The mortar by which the stones or bricks of the walls are held together has been obtained by burning limestone in kilns. The iron used in the house was first of all in the state of a dull red or brown stone, which had to be roasted and melted before the clear, bright metal came out of it.

But although these various stones differ so much from each other, they agree in one point—they come from underneath the surface of the ground. If you could trace back each of them to the place from which it came, you would find that the freestone and limestone were taken out of quarries, perhaps not very far away, that the slates were cut out of the side of some hill, probably in Wales, that the marble was quarried out of some distant mountain, possibly in Italy, that the coal was dug out of mines, sunk deep into the earth in some part of Britain, and that the bricks were made from clay dug out of pits on some low ground in your neighborhood.

In this country the greater part of the surface has a green grassy covering even over the sides of the hills—cornfields, meadows, woods, and orchards spread over it, concealing what lies beneath them, as a carpet conceals a floor. But this mantle of vegetation with the soil on which it grows is only a thin coating. You can easily dig through the grass and soil, or, better still, you can watch their removal in quarries, pits, or excavations of any kind. You find them to form a mere outer layer only a few feet thick at the most. Underneath them there always lies some kind of stone. So that just as in pulling up the carpet of a room you lay bare a wooden floor, so in peeling off the outer skin of vegetation and soil from any part of the land you expose a stone floor.

On this floor of stone we are walking every day of our lives. It stretches all over the globe, forming the bottom of the sea and the surface of the land. Unlike the floors of our houses it is very uneven, as you well know. In some places it spreads out into wide flat plains, elsewhere it shoots up into high and rugged mountains.

Again, this vast world-wide floor differs from our little wooden floors in the wonderful variety of its materials. You see only a small part of this variety in the various stones we use in building. There is an almost endless number of other stones. A builder is content if he can get his floors made of one uniform sort of wood which will last. But the great stone floor on which we are living has no such uniformity. Its varied materials are grouped together in the most irregular and changing manner, insomuch that if you made a map of them all, it would be like the intricate pattern of some costly carpet.

It is this stone floor of which I wish to speak to you in the following lessons—what it is made of and how its different parts were put together. At first sight, perhaps, it may seem to you that there can be nothing very interesting or attractive about such a subject. Let me show you how it is related to you by the following illustration.

Take a map of the British Islands and draw across it two penciled lines. Let one of these lines begin at Liverpool and stretch across England, touching Stafford, Birmingham, and Cambridge, to the sea at Harwich. Let the other run across the breadth of Scotland from the island of Skye to Montrose.*

Suppose that two foreigners who had never been in this country were to land on the west coast, and after crossing the island, each along one of the lines you have drawn, were afterward to meet again on the Continent and compare notes as to what they had seen. The traveler who journeyed along the line from Liverpool to Harwich might report in some such words as these: "I am astonished at the flatness of Britain. I went across the whole breadth of the island and did not see a single undulation of the ground worthy of the name of a hill. Most of the land is wonderfully fertile, being in one part covered with cornfields, in another with orchards or woods, while wide tracts are given up to pasture. The houses are built of brick. I saw some large cities crowded with people and alive with all kinds of industry. I noticed, too, that in some parts of the country a great deal of the wealth of the inhabitants came from under ground. In Cheshire they bring up large quantities of salt from mines. In Staffordshire they extract coal and iron from numerous deep pits. But on the whole, Britain seems to me given up chiefly to the growing of corn and the feeding of cattle."

The other traveler would have a very different story to tell. "I cannot understand," he might say, "how you can talk of Britain as in any sense a flat country. I too crossed the island from sea to sea, landing on the coast of Inverness-shire and sailing from the port of Montrose. But I could see very little low or level land the whole way. It is one interminable succession of rough high mountains and deep rocky valleys. I could see no towns, hardly any villages, until I came to the eastern coast. The people live in houses of stone; I could not see a single brick anywhere. They have no coals except what are brought from a distance, and most of the poorer people cut the peat on the hills and use it for fuel. I saw no mines in my journey, and no manufactures of any kind. The population is but scanty, and seems to be occupied chiefly with sheep farming. If I might judge of the whole of Britain from what I have seen with my own eyes, I would describe it as a rough, mountainous, barren island, without commerce or industry, and fit only for pasture land or grouse shooting, and here and there for tillage."

Now, each of these supposed travelers would have given a true enough account of this country so far as his own personal experience of it went. And yet both of them would have been quite wrong in supposing that what he had seen to be true of one part of the country was true in like manner of the whole.

But why is it that there should be this great difference between different portions of Britain? What makes one region mountainous, another level; one fertile, another barren; one crowded with people and the scene of all manner of industry, another thinly peopled and given up to the rearing of sheep and the shooting of game?

These great differences of the surface of the country depend upon differences between the stones or rocks.

Now, you can easily understand that if so much of the character of a country and of its inhabitants depends upon the nature of the stones underneath, it is very desirable that we should know something about these stones, how they came to be formed, what they consist of, and how it is that they should form plains or low grounds in one place, and single hills or lofty mountains in another. This kind of knowledge belongs to the science of geology.

DIFFERENT KINDS OF STONES.

If I were to ask you how many different kinds of books you have seen in the course of your lifetime, you would perhaps say that it was quite impossible to count them. You have seen many that were new, some that were old; big books and little books; some with boards, others merely wrapped up in paper; some beautifully bound in cloth of red, green, blue, or other colors, others cased in leather and covered with rich gilding; some printed in large, others in small letters; and some plentifully supplied with pictures, others without any at all. In short, you might go on for a long time trying to count up all these differences among the books which you have met with. But now if you think a moment you will see that, after all, these are only outside differences. The really important part of the book is not the binding, or the paper, or the printing, but the words which the book has to make known to you. You might print these words in very small type and make them up into a little book, or in very large and widely spaced type, and make a big book; you might put in pictures or leave them out; you might bind the book in cloth or in leather, or give it no binding at all; but still it would be in reality the same book all the time.

When you pass, then, from such mere unimportant external resemblances or differences to what the books properly are in themselves, you soon discover that after all there are not so many kinds as you had imagined. You can pick them out and sort them into groups according to the subjects of which they treat. Thus in your little libraries you find that some are books of grammar, others books of history, others books of geography, with books of poetry, books of travels, books of tales, and so on. Under each of these names you could put, if you had them, hundreds of books, resembling each other in treating about the same things, whether they were old books or new, large or small, bound or unbound.

In arranging your books in this way, not according to their mere superficial accidental resemblances, but according to the subjects which they treat of in common, that is, their real resemblances, you would follow what is called a principle of classification. It would not matter how many different books came into your hands; they might be written, too, in English, French, German, Latin, Greek, or in any language. Still, following your principle of classification, you would be able to arrange them all in their proper places, all the books on the same subject being put together, so that at any moment you could lay your hands on any particular book which might be wanted.

Suppose that instead of books you are asked to arrange stones according to their several kinds. You think over the names of all the different stones you know and try to recollect their characters. Perhaps you begin by arranging them according to color, as for instance black stones, such as coal; white stones, such as chalk. But in a little time you find that the same stone, marble for instance, is sometimes black and sometimes white. Plainly, therefore, color will not do for your principle of classification among stones, any more than it would do for books. Then you might go on to see how a grouping into hard stones and soft stones would do. But as soon as you begin this kind of classification, you find that you need to put side by side stones which are so utterly unlike each other that you feel sure that mere hardness or softness is one of those accidental or outside characters, like the paper or printing of a book.

You must find out then what are the real and essential characters of stones. Now, how did you do this in the case of books? You examined their contents, and placed those together which on reading them you found to be devoted to the same subject. You must follow the same course with stones.

But you may ask, "How are we to read the contents of stones? Surely this must be very difficult, for is there not an infinitely greater number of kinds of stones than of books?" By no means. You will soon learn that it is not so difficult as you might suppose to read the contents of stones, and that in reality the chief groups of stones are very much fewer in number than the chief groups of books. Let us see.

Here are three pieces of stone:

1. A piece of sandstone.
2. A piece of granite.
3. A piece of chalk.

You are quite familiar with each of these kinds of stone. Sandstone is a common material for walls, lintels, hearths, and flagstones. Granite may now be

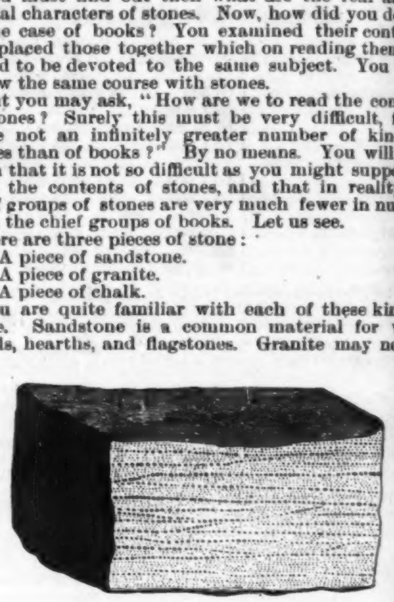


FIG. 1.—Piece of Sandstone.

frequently seen in polished columns and slabs in public buildings, shops, and in tombstones; and the streets in many of our large cities and towns are now paved with it. Common white chalk is well known to everybody.

Take the piece of sandstone in your hands and examine it carefully, using even a magnifying glass if the grains are minute. Then write down each of the characters you observe one after another. You will of course pay little heed to the color, for sandstones, like books, may be red or white, green or yellow, or indeed of almost any color. Nor will you give much weight to the hardness or softness as an essential character, for you may find even in a small piece of the stone that one part is quite hard, while a neighboring place is soft and crumbling.

If your piece of sandstone has been well chosen for you, you will be able to write down the following characters:

(1.) The stone is made up of small grains.
(2.) The grains are all more or less rounded or worn.
(3.) By scraping the surface of the stone these rounded grains can be separated from the stone, and when they lie in this loose state they are seen to be mere grains of sand.
(4.) More careful examination of the stone shows that the grains tend to lie in lines, and that these lines run in a general way parallel with each other.
(5.) The grains differ from each other in size and in the material of which they are made. Most of them consist of a very hard white or colorless substance like glass, some are perhaps small spangles of a material which glistens like silver, others are softer and of various colors. They lie touching each other in some sandstones; in others they are separated by a hard kind of cement which binds them all into a solid stone. It is this cement which usually colors the sandstone, since it is often red or yellow, and sometimes green, brown, purple, and even black.

Summing up these characters in a short definition, you might describe your sandstone as a stone composed of worn, rounded grains of various other stones arranged in layers.

Proceed now in the same way with the piece of granite. You find at once a very different set of appearances, but after a little time you will be able to make out and to write down the following:

(1.) The stone contains no rounded grains.
(2.) It is composed of three different substances, each of which has a peculiar crystalline form. Thus one of

* A similar illustration has been used by Buckland, in his Bridgewater Treatise.

these, called feldspar, lies in long smooth-faced, sharply defined crystals of a pale flesh color, or dull white, which you can with some difficulty scratch with the point of a knife. These are the long white sharp-edged objects shown in the drawing (Fig. 2). Another, termed mica, lies in bright glistening plates which you can easily scratch and split up into thin transparent leaves. If you compare these shining plates with the little silvery spangles in the sandstone, you will see that they

FIG. 2.—Piece of Granite.

are the same material. The third, named quartz, is a very hard, clear, glassy substance on which your knife makes no impression, but which you may recognize as the same material out of which most of the grains of the sandstone are made.

(3.) The crystals in granite do not occur in any definite order, but are scattered at random through the whole of the stone.

Here are characters strikingly different from those of the sandstone. You might make out of them such a short definition as this: Granite is a stone composed of distinct crystals not laid down in layers, but irregularly interlaced with each other.

Lastly go through the same process of examination with your piece of chalk. At first sight this stone seems to have no distinct characters at all. It is a soft, white crumbling substance, soils your fingers when you touch it, and seems neither to have grains like the sandstone nor crystals like the granite. You will need to use a magnifying glass, or even perhaps a microscope, to see what the real nature of chalk is. Take a fine brush and rub off a little chalk into a glass of clear water; then shake the water gently and let it stand for a while until you see a layer of sediment on the bottom. Pour off the water and place a little of this sediment upon a piece of glass, and look at it under the microscope or magnifying glass. You will find it to have strongly marked characters, which might be set down thus:

(1.) The stone, though it seems to the eye much more uniform in its texture than either sandstone or granite, is made up of particles resembling each other in color and composition, but presenting a variety of forms.

(2.) It consists of minute shells, pieces of coral, fragments of sponges, and white particles, which are evidently the broken-down remains of shells. In Fig. 3 you see some of these chalk grains as they appear when

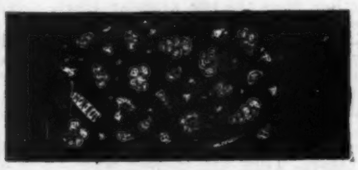


FIG. 3.—Some of the Grains of a Piece of Chalk.

you place them under a microscope which magnifies them fifty times. Larger and well-preserved shells, sea urchins, and remains of other sea creatures occur embedded in the chalk. (See Fig. 23.)

As a brief description of chalk you might say that it is a stone formed out of the remains of once-living animals.

You should repeat this kind of examination again and again until you get quite familiar with the characters which have been written down here. And you will see why it is important for you to do so when you come afterward to find out that these three stones are examples of the three great groups into which most of the rocks of the world may be arranged. So that when you master the composition of a piece of sandstone, or chalk, or granite, and learn how each stone was formed, you not only do that, but lay a foundation of knowledge which will enable you to understand how by far the greater part of the stones of our mountains, valleys, and seashores came into existence.

In spite then of the apparently infinite diversity of the stones of which the globe is built up, you see that by a little study they may be grouped into very few classes. You have to follow a simple principle of classification, and each stone you may meet with falls naturally into its own proper group. You do not concern yourselves much with mere outer shape and hue, but try to find out what the stone is made of, and ask whether it should be placed in the sandstone group, or in the granite group, or in the chalk group.

WHAT STONES HAVE TO TELL US.

But if you went no further than merely being able to arrange stones under their proper divisions it would be hardly worth your while to study them at all. You would be like people who could put a library into such excellent order that every volume should stand on its proper shelf and compartment, ready for easy reference at any moment, but who should rest content with this mere systematic arrangement and never open any of the books to make themselves acquainted with the contents as well as with the boards. The classification of stones, or flowers, or birds, or fishes, or any other objects in nature, is in itself of no more service than such an arranging of a library, unless you use it in helping you to understand better what is the nature of the things you classify and how they are related to each other.

This habit of classifying what we discover lies at the base of all true science. Without it we could not make progress; we should always be in a maze, and would never know what to make of each new thing we might find out. We should be like people turned into a great hall and required to educate themselves there, with the floors and walls strewed all over with piles of books in all languages and on every subject, but utterly and hopelessly in confusion.

Let us now try what this habit can do for us among the seemingly endless varieties of stones with which the world is stored.

We take again our three pieces of stone—sandstone, chalk, and granite—and compare other stones with them. We get out of town to the nearest pit or quarry or ravine, to any opening in fact, either natural or artificial, which will enable us to see down beneath the grass and the soil of the surface. In one place we may find a clay pit, in another a sandstone quarry, in another a railway cutting through chalk or limestone, in another a deep ravine in hard rocks with a stream flowing at its bottom. It does not matter for our present purpose what the nature of the opening be, provided it shows us what lies beneath the soil. In all such places we meet with stone of some kind, or of many different kinds. By a little practice we learn that these various sorts of stones may be usually arranged under one or other of the three divisions of which mention was made in last lesson. For example, a large number of stones will be found answering to the general description which you found to be true of sandstone. These will of course be placed together with our piece of sandstone. Another considerable quantity of stones will be met with made up wholly or almost wholly of the remains of plants or of animals. These we arrange in the same division with our piece of chalk. Lastly, a good many stones may be met with built up of crystals of different kinds, and these, for the present, we class together with our piece of granite.

In this way you would advance from the mere pieces of stone which you can hold in your hand up to the masses of stone lying under a whole parish or a county or even the entire kingdom. You would learn that a long range of hills, stretching completely across England from the coasts of Dorsetshire to those of Yorkshire, is formed of chalk, and that other parts of the country lie upon kinds of stone in many respects resembling chalk. You would soon discover that a great part of Britain is made of stone like your piece of sandstone, for example the hills and dales of most of Wales, Lancashire, and the south of Scotland. And if you climbed up to the tops of some of our highest mountains, such as Ben Nevis, you would see them to be built up of solid masses of granite, quite similar to your little specimen, or of other sorts of stones belonging to the same division as granite.

You would begin to perceive that the different kinds of stone are not scattered at random over the country, but have each their own places, with their own kinds of hills or valleys.

But a little further attention to these matters would bring before you a far more wonderful thing. In questioning the stones about how they were made, you would learn by degrees that each of them can give you a more or less distinct answer. In fact, they may be compared to books each of which has a little piece of history to tell.

You do not grudge to read books of history. You find much interest in following the changes which happened in old times in your country, how battles were fought, and laws were made, and old customs gradually passed away. You have no doubt found that the more you know about these events of former times, the better do you understand how the laws and customs of the present day came to be what they are.

Well, the solid earth under your feet has a history as well as the people who have lived on its surface. Take Britain for example. You will learn that once a great part of this country as well as of Europe and North America was buried under ice like Greenland. Earlier still it had jungles of palms and other tropical plants; yet further back it lay beneath a wide, deep ocean; and beyond that time can be traced many still more remote periods, when it was forest-covered land or wide, marshy plains, or again buried under the great sea. Step by step you may follow this strange history backward, and with as much certainty as you trace the doings of Julius Cæsar or William the Conqueror.

Now, the records of all these old revolutions of the earth's surface are contained in the stones beneath your feet. In learning what these stones are, how they were made and how they came to be as you now see them, you are really unraveling a part of the history of the earth. Even the commonest bit of stone has its own part of the story to tell you. If you are sure that it was well worth your while to go through the trouble of learning to read for the sake of all the knowledge which you can gain from books, you will discover, too, that you will be fully repaid for any pains you take in acquiring a knowledge of how to read the meaning of the stones. This earth history is written in clear and legible language which with a little patience you will easily master. And when you have once acquired it you will not be content with what you can learn from books. It will then be a constant and increasing source of delight to you to get away to the quarries and brooks, and sea shores and hill sides, to any place in short where the rocks stick out to the surface, that you may question them and learn what they have to tell about the ancient revolutions of the earth.

The object of this little book is to set you in the way of putting such questions to every stone and rock you may meet with. We shall begin with the very simplest lessons and appeal at every step to things which are already familiar to you. In this way you will feel how sure and steady your progress is, and in the end you will be able to carry on the questioning yourselves without much help from book or friend. By watching what takes place from day to day, as in a brook or by the shore of the sea, you will understand the events which have happened in long past times, and be able to decipher among the rocks that wonderful earth history which it is the business of geology to study and record.

SEDIMENTARY ROCKS.

I. What Sediment is.

We have now advanced some way in the attempt to understand what stones are. We have learned that they are full of a history of old revolutions of the earth, and that we may find out what this history is, but that in order to make any progress we must arrange into distinct groups the various stones which we mean to study. We have found, too, that they may be divided into three great groups or classes, each having a set of well marked characters.

To each of these groups names must be given. We might call them the sandstone group, the chalk group, and the granite group. But it happens that other names have been already in use, which will be more convenient. Accordingly, we shall refer all stones having characters like those of sandstone to the sedimentary rocks; those formed of the remains of plants or animals, as chalk is, to the organic rocks; and those having a crystalline character, like our granite group, to the igneous rocks. The meaning of these names will be seen as we proceed.

The word "rock" is applied to any kind of natural stone, whatever may be its hardness or softness. In this sense, sand, mud, clay, peat, and coal are rocks, as much as sandstone, limestone, or granite.

Now, it is evident at the very outset that each of these groups, since it is so well defined from the others, must have a history peculiar to itself, that is, its various kinds of stone or rock must have been formed differently from those of the other groups, in order to be so unlike them. Let us then take up each of the groups in succession, beginning with the sedimentary rocks, that is, with those which have a more or less close resemblance to sandstone.

But first we must understand the meaning of the word sedimentary, and why it is applied. We take a glass of water and put some gravel into it. The gravel at once sinks to the bottom and remains there even though we stir the water briskly. We close the mouth of the glass and shake it up and down so as to mix the water and gravel thoroughly together; but as soon as we cease to do so and place the glass on the table again, we see that the gravel has sunk and formed a layer at the bottom. This layer is a sediment of gravel.

Instead of gravel we put sand into the water and shake them up as before. We mix them so completely that for a moment or two after we cease the water seems quite dirty. But in a few minutes the sand will have all sunk to the bottom as a layer below the water. This layer is a sediment of sand.

We take a little mud or clay, instead of either the gravel or sand, and shake it up in the water until the two are thoroughly mixed. When the glass is replaced on the table this time, the water continues quite dirty. Even after some hours it remains still discolored, but we see a layer beginning to appear at the bottom. If the glass is allowed to stand long enough undisturbed, that layer will go on growing until the water has again become clear. In this case the layer is a sediment of mud.

Sediment, therefore, is something which, after having been suspended in, or moved along by, water has settled down upon the bottom. The coarser and heavier the sediment the quicker will it sink, while, when it is very fine, it may remain in suspension in the water for a long time.

Sedimentary rocks must thus be those which have been formed out of sediments. And just as sediments differ from each other in coarseness or fineness, so will the sedimentary rocks formed out of them.

Here are pieces of three sedimentary rocks:

(1.) A piece of conglomerate or pudding stone (Fig. 4).

(2.) The piece of sandstone you have already looked at (Fig. 1); and

(3.) A piece of shale (Fig. 5).

Examine the first of these three specimens. You find it to be made of rounded little stones, firmly cemented

FIG. 4.—Piece of Conglomerate or Pudding Stone.

together. Were these rounded stones to be separated from each other, and gathered into a loose heap, you would call it a heap of gravel. The stone is evidently nothing more than a hardened gravel, such as you might pick up on the seashore or in the channel of a stream. It is sometimes called pudding stone, because the stones lie together somewhat like the fruit in a plum pudding.

Take up the piece of sandstone again, and make a further examination of it. Did you ever see anything like the grains of which it is made up? You reply that

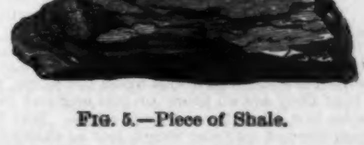


FIG. 5.—Piece of Shale.

they are mere grains of sand such as might be met with anywhere. And you are quite correct. The sandstone consists of nothing else but sand firmly held together so as to form a stone. If you went down to the seashore, or to the bed of a brook or river, you could gather sand of very much the same kind, and by hardening such sand into a compact mass you might make sandstone.

In the third specimen you cannot so easily make out what the grains of the stone are, since their size is so small. But take a knife and scrape a little of the end of the stone and work it up with some drops of water. You will make a kind of paste in this way. Then put this paste into a tumbler of water and

stir it well round. Immediately the water gets dirty-looking, and remains so even for some time afterward. But put the tumbler aside for some hours, and you will find that the water becomes clear again; that what you put in as a dirty paste has sunk to the bottom of the glass as a layer of sediment, and that it is simply mud. The shale, therefore, is nothing more than a stone formed of fine muddy sediment, just as the conglomerate is formed out of coarse gravelly sediment.

Thus you see that the term sedimentary rocks is a very expressive one, for it includes stones formed of all kinds of sediment, whether coarse or fine.

Look again at any one of our three specimens, and you will understand that we have two things to find out about them. First of all, how was the sediment made out of which they have been formed? and secondly, how did the sediment come to be gathered and hardened into solid stone?

II. How Gravel, Sand, and Mud are made.

You have taken the first step in the study of the sedimentary rocks—you now know that they are made of sediment such as gravel, sand, and mud. The next step must be to find out where this sediment came from and how it was formed. If you can settle this matter, you will evidently know a good deal more about the history of these rocks. And here, as in all such matters, you will find it well to ask yourselves at the very outset: Is there anything going on nowadays which will explain what we are in search of? By starting fresh from the observation of what takes place at the present time, you will be far better able to understand what has been done long ago. How then are gravel, sand, and mud made at the present day?

A little attention will show you that the difference between gravel and sand is only one of degree of coarseness. In gravel the stones are large, in sand they are mere grains. To make this clear, place a little sand under a strong magnifying glass, which will make the grains appear much larger than they really are, so large, indeed, as to give them the look of gravel stones rather than grains of sand. You can then see that each grain is a worn, rounded stone, sometimes with little chips and hollows on its sides, just like those on the sides of any pebble we may pick out of a heap of gravel. The longer you look at the sand in this way, the more sure do you become that, after all, sand and gravel are just different states of the same thing, the one being merely coarser than the other.

If you were to search on the shore of the sea, or on the banks of a river, you could without much difficulty prove in another way that sand and gravel only differ from each other in the size of their grains. You might gather handfuls of fine sand, then of sand a little coarser in the grain, and so on by degrees until the material became a true gravel, with rounded pieces of stone of all sizes, from mere little pebbles up to blocks as big as your head. How did all these fragments, whether small or large, come to be broken off and ground so round and smooth, and heaped up where we now find them?

Let us get away up among the hills, and watch what goes on where the brooks first begin to flow. Where the rocks are hard and tough, they rise out of the hillsides as prominent crags and cliffs, down which the little streamlets dance from ledge to ledge before they unite into larger streams in the bottoms of the valleys. Now look at those crags. See how they are split up and wasted by the rains and frosts. You have learnt already something about how this is done. But you have now to consider some of the results of the waste.

Suppose, for the sake of distinctness, that we single out one special crag where the rock is of some bright color, say red, and differs in that respect from the rest of the crags round about it. It rises out boldly from a steep hillside, and looks down a long slope to the little stream which in the distance seems a thread of silver winding through the green meadows far below us. Our crag has been sorely wasted in the long course of time. The rains and frosts of many centuries have carved its sides into deep clefts and gullies. These, when wet weather sets in, become each the channel of a foaming torrent, which pours headlong down the slope and sweeps away every loose bit of stone or earth within its reach.

We climb cautiously along the face of the crag to look into some of these frost-splintered, torrent-swept gullies, and then we descend to the base. All the slope below is strewn with pieces of the crag. Some of these are huge blocks, but most of the material forms a kind of mere rough rubbish, which slides down the slope with us as we descend with long strides to the bottom. Each of the deep clefts which have been scooped out of the crag has a long slope of this kind of rubbish lying below it. You cannot for a moment doubt that all this broken-up material on the slope actually formed at one time part of the crag itself, that in fact it is simply the material which has been removed by the slow wasting away of the sides and bottoms of the clefts, and that if you could gather it all up again so as to put it back where it formerly stood, you would really fill the clefts up.

The slope leads us down to a little brook, the bed of which is strewn with pieces from our crag. Now let us descend the brook and look at its channel carefully as we go. The red fragments from that crag will be easily distinguishable from the other dull gray stones, which have been detached from the rest of the crags on either side. If you look narrowly at the bits of stone which are strewed about upon the slope, you will notice that they are all more or less angular in shape, that is to say, they have sharp edges. But those in the brook are not quite so rough nor so sharp-edged as those on the bare hillside above. Follow the brook down the valley for some way, and then take another look at the stones in the bed of the stream. You do not now find so many big blocks of the red stone, and those you do meet with are more rounded and worn than they were near the crag. They have grown smooth and polished, their edges have been worn off, and many of them are well rounded. Once more you make a further examination still lower down the valley, and here and there where the stream has thrown up a bank of gravel, you find that the pieces of our red crag have been so well ground away that they now form part of an ordinary water-worn gravel.

In the same way by descending the stream still further you could trace the gravel becoming finer and passing at last into sand. And if you were to place some of this sand under a magnifying glass, you would find it partly made up of more or less rounded grains of the same red stone which you detected in the gravel, and which you knew to have come from our crag far up in the hills.

Now, how is it that the stones get worn down in this way? Why should lying in the bottom of a stream make them smaller?

If you watch the stream only in fine weather, when the water is low and the current feeble, you can hardly judge as to the real power of the water. Come back when heavy rains have filled every gully in the hills with a foaming torrent, and when every streamlet rushes headlong down its valley, filling its bed to the brim and even rising high on either side. You cannot now see the stones on the bottom of the channel, but listen and you can hear them. That sharp rattle which every now and then comes out of the water is caused by the stones thumping against each other, as they are hurried along by the rushing water. They are kept grinding against each other as in a mill. Of course, they must needs have their edges worn off, and their sides smoothed, while at the same time they smooth and polish the rocks of the channel over which they are driven.

When the stones first fall or are swept from the hillside into the brook, they are, as you saw, mere angular chips (Fig. 6). But by the time they have traveled

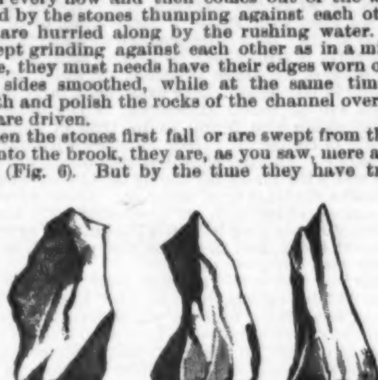


Fig. 6.—Stones detached from a cliff by rains, frosts, etc., and launched into a brook.

down the brook a little way, and have suffered from the grinding of a few floods, they lose their sharpness. The smoothing and polishing process goes on till they become more or less rounded, and at last appear as well-worn gravel (Fig. 7). A rounded stone will travel

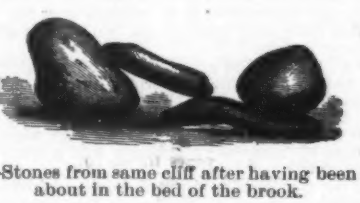


Fig. 7.—Stones from same cliff after having been rolled about in the bed of the brook.

farther and faster than an angular one, but in the end gets worn down into mere sand (Fig. 8).

Thus we see that as the stones grow rounder they at the same time become smaller. And not only do they wear away each other, they also grind out the sides

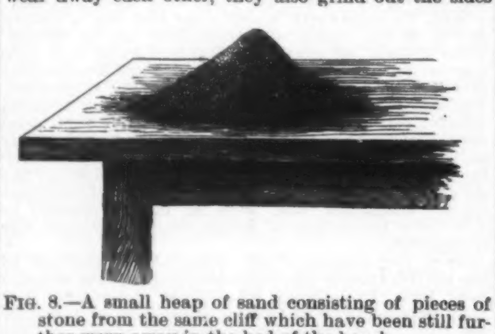


Fig. 8.—A small heap of sand consisting of pieces of stone from the same cliff which have been still further worn away in the bed of the brook.

and bottom of the channel of the brook. A good deal of stone must be consequently rubbed down. Now, it is this worn material which makes gravel, sand, and mud. In the bed of every stream you will never fail to find plenty of this worn material, derived from the rubbing away of stones by water.

The finer particles, being more easily moved, travel much farther than the coarser fragments. Hence, while the gravel and coarse sand are pushed along the bottom, the find sand and mud are suspended in the moving water and may be carried by it for many miles before they slowly sink to the bottom to form there a deposit of silt or clay (Fig. 9).

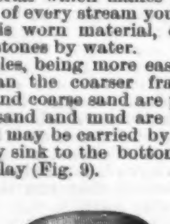


Fig. 9.—A glass of water taken from the same brook when in flood, to show how the finer particles worn from the same stones settle down on the bottom as a layer of mud.

You will see from this, that while the brooks in the higher parts of the country may have their channels encumbered with big blocks of rock, and quantities of coarse, sharp, angular rock-rubbish, all this material is worn down by degrees, and reaches the lowlands or the sea only as find sand and mud. As the brooks are always flowing, so are they always transporting the worn materials of the hills. But as fast as they do so, the hills are crumbling down and supplying fresh materials to the brooks. So that the amount of gravel and sand ground up every year even by the comparatively small streams of this country must be enormously great.

We can now return to our crag of red rock with freshened interest. Every cleft and gully which has been worn into its sides bears witness to the general crumbling which the surface of the land undergoes. We may follow its ruined blocks and rubbish into the brook below, watch how they are ground down there, and trace them onward until in the form of fine silt and mud their remains find their way at last into the far distant plains and thence to the bottom of the great sea.

But it is not only in the beds of brooks and rivers that you can watch how the hardest rocks are ground away into gravel and sand. Look at any of the rocky parts of the coast line of this country and there mark the effects of the waves of the sea. If a cliff rises from the upper edge of the beach, you can at once tell which parts are exposed to, and which lie beyond, the reach of the waves. Overhead the cliff is rough and splintered where merely rain, frost, or springs have acted on it. But toward its base the rocks have been ground smooth and polished like those in the bed of a mountain brook. What has smoothed the bottom of the cliff and left all the higher parts rough and crumbling? The waves have done it.

Huge slices of the weather-roughened cliff have been detached and have fallen down on the beach below. Others are ready to tumble off. Examine the fallen blocks and you will see that usually only those lying at the base of the cliff, and which have not yet been moved by the waves, have still their sharp edges. A little lower down the blocks show signs of having been ground together, while the greater part of the beach is strewn with stones of all sizes, well rounded and polished.

On a calm day when only little wavelets curl on the shore you cannot easily judge what the sea really does in the way of grinding down the beach and the bottom of the cliffs, just as you could not form a proper notion of the work of a brook merely by seeing it lazily creeping along its bed in a season of drought. But place yourselves near a cliff during a storm, and you will not need any further explanation as to the power of the waves to grind down even the hardest rocks. Each huge breaker as it comes tossing and foaming up the beach lifts up the stones lying there and dashes them against the base of the cliff, where it bursts into spray. As the green, seething water rushes back again to make way for the next wave, you can hear, even perhaps miles away, the harsh roar of the gravel as the stones grate and grind on each other while they are dragged down the beach, only to be anew caught up and swept once more toward the base of the cliff. You could not conceive of a more powerful mill for pounding down rocks and converting their fragments into well-worn gravel and sand. Just as in the channel of every stream, so along the shores of every sea you meet with the fragments of the rocks of the land in all stages of destruction, from the big angular block down to the finest sand and mud.

If, therefore, I now repeat the question, "How are sand and gravel made?" you will at once answer—"Sand and gravel are part of the material worn away from the surface of the land, and ground down in moving water." Materials which have been rubbed smooth in this way are said to be "water-worn." But you will now see that it is not the water which of itself wears them away. They are in fact worn away by themselves, and all that the water does is to keep them moving and grinding against each other.

III. How Gravel, Sand, and Mud become Sedimentary Rocks.

We have now got so far on our way as to understand whence the materials of which sedimentary rocks are made were derived. But the further question remains, How have these materials been gathered together and hardened into solid stone? As before, we must find the answer to such questions in what we can see going on around us. By turning back again to the brooks, rivers, and sea, we shall get this next matter very clearly explained.

Water flows more quickly down a steep slope than over a gentle one. You know that when you raise one end of a tray, water poured on it runs down to the lower end, and does so the faster, the steeper you make the inclination.

If you put crumbs or pebbles of different sizes on the tray, you will notice that they are swept down more by the rapid than by the slower flow of water. A quickly flowing current of water is more powerful to move anything than one which flows slowly. Hence, as you will at once see, there must be great differences in the size and weight of materials which different streams or different parts of the same stream can move.

So long as a current of water is moving swiftly, it keeps the gravel, sand, and mud from settling down on the bottom. You remember that when you put some of each of these materials into glasses, and kept the water in rapid motion, they continued suspended in the water, and only sank to the bottom as the water began to lose its motion, the gravel first, then the sand, and last of all the mud. Now, this is just what takes place in all the moving waters of the globe. A rapid current will hurry along, not only mud and sand, but even gravel. As its rapidity flags, first the gravel will sink to the bottom as a sediment, the sand will sink more slowly and be carried further, while the mud will hang in the water for a long time, travel a much greater distance, and only fall with extreme slowness to the bottom.

You must test the truth of these statements the first time you have an opportunity of looking into the rocky channel of a brook as it escapes from the hills. Get to some part where the water, shooting swiftly over ledges and rocks, has strength enough to sweep even big blocks of stone along with it. A little way further down you will find the channel less steep and the current less strong. Now look into the bottom of the stream. Is it covered with fine mud? Assuredly not. You meet one with big blocks of stone and coarse gravel. These have been dropped as soon as the water had its force checked by coming from a steep to a more level part of its course. But it still had power enough to transport the finer sorts of sediment. You

need to go further down toward the low grounds before you see the bed of the stream covered with sand, and much further yet, even far into the plains, before you meet with layers of mud.

After seeing these things with your own eyes, you would be convinced that wherever you find masses of gravel they tell you of strong currents of water, that beds of sand point to less rapid currents, while sheets of mud show where the water has had either a very gentle motion or has been quite still, so as to let the fine sediment settle down quietly on the bottom.

Now see how important this knowledge becomes when you begin to inquire how different stones were made. If you have ascertained clearly how various kinds of sediment are formed, you have got a long way toward understanding how sedimentary rocks came to be made. These rocks may be hard stone now, and may be used for paving streets or building houses. But you have learned that mere hardness or softness goes for little, and that it is the materials of which the stone consists that you have to consider. When you find these materials to be water-worn grains of mud, sand, or gravel, you confidently assert that, no matter how hard the stone may be now, it was once in the state of mere loose sediment under water.

But you can tell more than this. By seeing the kind of sediment of which a rock is made up, you know something about the nature of the water in which the materials of the rock were laid down. For instance, you recognize a rock of conglomerate to be only a mass of compact gravel, and you are sure that, like ordinary gravel nowadays, it was rolled about in shallow water such as the bed of a lake or river or on the shore of the sea. Again, you see in a rock formed of fine mud, such as shale, proofs of deeper or stiller water into which only the finer particles worn away from the land were carried.

We have watched how the sediments are ground down by brooks, rivers, and waves; let us now follow them until they are gathered into places where they can accumulate without being constantly washed away.

Some account has already been given of what becomes of the materials worn away from the surface of the land. You have learned how they are washed down by rains into brooks and rivers, how they are there ground down, and how finally they are borne as fine sand and mud away out to the bottom of the sea. Now these deposits of sediment over the sea bottom will by and by become hard sheets of stone, like the common sedimentary rocks we have been dealing with in these lessons. You cannot see what goes on under the sea, but you can form some notion of it by watching what takes place in pools of water on the land.

Let us suppose that we know a muddy street or road which slopes down gently to a more level part, and that in wet weather the rain gathers in pools at the bottom of the slope. We choose a wet day, and after following the course of one of the gutters down the slope and noticing how the muddy water sweeps along sand, gravel, bits of cork, stick, paper, and whatever lies in its way, we halt at a large pool which has gathered on the road, and into which the current of muddy water is discharging itself. So long as the water flows quickly downward, it sweeps away gravel and sand. But see what happens when it begins to flow more slowly over the flat at the bottom and enters the pool. By losing speed it loses carrying power, and must needs drop some of its burden of sediment. The heaviest particles fall to the bottom first, and this takes place just where the current is checked by meeting the level water of the pool. Now mark the result. That part of the pool where the current enters is gradually filled up, except the channel which the current keeps open for itself. You can see how this tongue of sediment is advancing upon the water, and that it will in the end, should the rain last long enough, fill the pool up entirely. It is only the coarse sand which collects there; the fine mud goes across the pool, and though part of it, as you will find, settles down on the bottom, much or most of it escapes at the further end of the pool, because the water has not had time, in its passage from the one side to the other, to drop its burden of mud.

Let us suppose further that, when the rain has ceased, no cart wheel or other intruder comes to disturb our pool, but that the water is suffered quietly to soak into the ground and to evaporate, so that in a day or two the hollow is laid dry. You can now examine the bottom of the pool and see exactly what took place when the muddy water filled it. Here at the upper end is the tongue of sand pushed out from the shore by the streamlet. You recognize it as a true delta. The bottom of the rest of the pool is covered with fine muddy silt or sand spread out over all the space on which the water lay.

With a knife we carefully cut a hole or trench through these deposits on the floor, so as to learn what they consist of from top to bottom. A cutting of this kind is called a section, and may be of any size. The steep side of a brook, the wall of a ravine, the side of a quarry or railway cutting, a line of cliff, are all sections of the rocks. Let us see what our section has to tell.

In the center of the little basin the sediment brought in by the rain has accumulated to a depth, let us say, of an inch, below which lies the ordinary surface of the roadway. Now, what feature strikes you first about this deposit of sediment when you come to look at the section which we have cut through it? Are the materials arranged without any order? By no means. If you made a drawing of the section, it might be something like the following woodcut (Fig. 10). The materials have been deposited in layers which have been laid down flat one above another. Some of these layers are finer, others coarser than the rest. But whether coarse or fine, they all show the same general arrangement in level lines.

In looking at these layers you can follow exactly how each of them was deposited. The coarse sediment is seen chiefly at the bottom, and marks where the stronger currents carried sand and bits of stone across the pool. But as the rain slackened, the runnels on the roadway grew less and the currents in the pool became feebler. Hence, instead of coarse sand, only fine silt was deposited, so that in the upper half, the layers are finer than they are in the lower. Together with the sand, gravel, and mud, you may notice chips of wood, leaves, and twigs (*c* in Fig. 10), which have been laid down among the layers of sediment.

You may think perhaps that observations such as these are too trifling, and that surely it cannot matter what rain may do in a little pool on a roadway, since we are not to judge of the world at large by what goes on upon so small a scale. In reality, however, if you thoroughly understand what takes place over the bottom of such a pool, insignificant though it may seem, you lay a foundation from which it will be easy for you to understand how sedimentary rocks are and have been formed all over the world.

Instead of the pool, imagine to yourselves a great lake such as that of Geneva, and in place of the mere tiny runnel on the road, formed by the sudden rain, and disappearing when the rain ceases, picture a great river like the Rhone, ever fed by the rains and snows and springs of a huge mountain chain. And yet though you make the scale on which the work goes on greater, the kind of work remains the same as in the pool. You look with wonderment on the river rushing so swiftly past, and tossing its muddy waters into wave

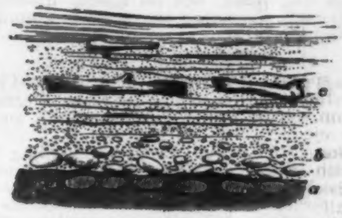


Fig. 10.—Section or cutting through the sediment brought by rain into a pool on a roadway. *a.* Surface of roadway. *b.* Layers of coarse sand with bits of coal and ash. *c.* Layer containing twigs, bits of straw, leaves, paper, etc.

and foam, from bank to bank. You watch it enter the lake, and mark how the waves one by one sink down, and how the river loses itself and its tumult in the quiet, silent water of the deep, blue lake.

But climb one of the mountains which rise steeply from either side of the upper end of the lake of Geneva. When you get up a few hundred feet, turn and look down upon the river and lake, and see if they do not strongly remind you of our runnel and pool on the road. The bottom of the valley lies spread out as in a map before you. The windings of the river, the flat, green meadows on either side running as a long tongue into the lake, the little cottages and hamlets, and the lines of road—all so dwindled down in the distance that you can see at a glance how they lie. That green tongue of meadows filling up the upper end of the lake and stealing along each side of the river is the delta. It has been formed in the same kind of way as the little delta in our pool, only instead of hours it has needed thousands of years for its formation. About a mile and a half from the edge of the lake, a little hamlet, standing among the level fields, was actually at the margin of the water some eighteen hundred years ago, and is still called Port Vallais. The river has thus pushed out its delta and filled up the lake for a mile and a half since Roman times.

From the high ground overlooking the head of the lake you can see, moreover, another curious fact about the way in which the sediment gathers over the bottom. The Rhone is very muddy, and as the mud has a white color here, the milky look which it gives to the water enables you to follow the course of the river into the clear blue lake. Looking down upon it from the heights, you can trace the pale muddy current for some way out from the shore until it gradually gets mixed with the lake water and disappears.

Go now to the lower end of the lake, and watch where the water escapes. Do you see any mud now? No; your eyes never looked on clearer, brighter, bluer, water than that which comes rushing and leaping between the banks and beneath the bridges of Geneva. What has come of that cloud of pale mud which you saw carried by the river into the upper end? It has all settled down upon the bottom. Day by day, year by year, and century after century, the cloud of mud is there, always sinking through the water to the bottom, and always renewed by the restless river.

Fig. 11.—Stratification of sedimentary rocks. *a.* Conglomerate. *b.* Sandstone. *c.* Shale.

Could you drain off all the water of the lake, you would find the floor covered with deposits of sediment stretching, not over a few square feet, as in our little wayside pool, but over many square miles. The coarser sediments—shingles and gravels—would be met with at the upper end where the strong current flowed, while the finer sediments—sand and mud—would cover the main part of the bottom.

If you were to bore through these deposits, you would find them in some places to be perhaps more than a hundred feet thick, and digging down anywhere among them you would see the same arrangement into flat layers which you observed in the rain pool. Sand, mud, and gravel might follow each other from top to bottom, but always in beds or layers lying one above another.

The Lake of Geneva is many thousand times larger than our little pool; and yet it is itself only a pool, and a very small one, when compared with the great sea. Go to the margin of the sea where a large river enters, and you will see that mere size does not alter the kind of work which the river and the sea are doing, and that in their case too you have the same process to study which you have watched already. You perceive how the river is continually carrying vast quantities of sand and mud into the sea. You can follow the muddy river water to a distance from the shore until, as its mud slowly sinks to the bottom, it loses itself in the waters of the ocean. You know that by this means the bottom of the sea for a long way from the coast is constantly receiving fresh deposits of sand and mud which have been washed off the land. The upper edge of these deposits is uncovered when the tide goes out. You can dig into them where they form the beach, and when you do so you recognize the same arrangement into layers as you found to be the case elsewhere.

In this way you gradually would come to be convinced that one grand leading feature of the sedimentary deposits laid down under water is that they are not mere random heaps of rubbish, but that they are assorted and spread over each other in regular layers. This kind of arrangement is called stratification, and the sediments so arranged are said to be stratified. So characteristic is this mode of arrangement among the sedimentary rocks, that they are often called also the stratified rocks.

The sheets of sand, gravel, or mud which can be seen on the seashore, or at any lake or pool on land, are soft or loose materials. Sandstone, conglomerate, shale, or any other sedimentary rock, is usually more or less hard or compact. How is this difference to be accounted for? You are quite sure that, in spite of their firmness, these rocks were once mere loose sediment formed under water in the same way as sediment is made everywhere at the present day. But what has turned them into hard stone?

If you take a quantity of mud, and place it under a weight which will squeeze the water out of it, you will find that it gets firmer. You can thus harden it by pressure. Again, if you place some sand under water which has been saturated with lime (that is, the material of which chalk and limestone are made), or with iron, or with some other mineral which can be dissolved in water, you will notice that as the water slowly evaporates, it deposits its dissolved material round the grains of sand and binds them together. Were you to continue this process long enough, adding more of the same kind of water as evaporation went on, you would convert the loose sand into a solid stone. In this case the hardening of the sediment into stone would be done by the process called infiltration.

In one or other or both of these ways most of the sedimentary rocks have been hardened into the state in which we now find them. When sand and mud are piled up over each other in wide sheets or layers, to a depth of hundreds or thousands of feet, the layers at the bottom, lying under such an enormous weight, must be squeezed into a much firmer condition than those at the top. But besides this, water is always filtering through pores and cracks of the rocks, sometimes removing, sometimes depositing, mineral matter and helping to cement the grains of many rocks more firmly to each other.

If I were now to ask you what an ordinary sedimentary rock is, you would readily give me, and clearly understand, such a definition as this: "A sedimentary rock is one formed from sediment which was derived from the waste of older rocks, and deposited in water. It usually shows the stratified arrangement characteristic of water-formed deposits. Since its original formation, it has usually been hardened into stone by pressure or infiltration."

(To be continued.)

[From the U. S. Consular Reports.]

COAL, ASPHALT, AND PETROLEUM DEPOSITS IN VENEZUELA.

Ever since the early Spanish explorations, the existence in this section of asphalt has been recognized, and that of coal suspected, but it was not until after the erection of Venezuela into an independent republic that these deposits began to attract attention.

In the year 1834 the Indians of the Goajira were making incursions into civilized territory, near the river Tocui, and during one of these raids various cattle owners from the town of Mojan, with a detachment of men mounted and armed, began an exploration of the forests which extend from the westward of that village as far as the foot of the mountains. Their object was to search for cattle which had been stolen by the Indians, and in the course of their investigations they encountered a phenomenon previously unknown to any one. In the side of one of the banks of a gully was an aperture, resembling a large cave, which shot forth, without intermission, smoke, flames, and burning cinders. The exploration here terminated, and on the return of the party its members gave their versions of the circumstances of the discovery of what they termed a volcano.

The government did not then occupy itself with the investigation of the position and character of this phenomenon, nor were there any individuals willing to undertake such a difficult exploration through large, uninhabited forests, intersected in all directions by deep gorges. The belief in the existence of a volcano became, however, universal, and fifteen years after the first discovery various residents of Mojan stated that for several days following the earthquake of May 3, 1849, there was seen in the direction of the mountains of Perija a great cloud of smoke during the day and at night a splendid brilliancy. Neither at this time did the government take any measures to ascertain the facts, and the public in general did not much occupy itself with the phenomenon, following, as it did, in the wake of a public calamity.

Later, however, after repeated efforts on the part of various individuals, the government was induced to appropriate a small amount for purposes of exploration. From the Sierra of Perija, in the part nearest the lake to the west of Maracaibo, stretch in a NNE. direction the hills called the Sierra de Tule, whose elevation is not very considerable, and with an extension of about 50 kilometers. To the west of these hills runs the river Tocuy, and on its east side are the head waters of the rivers Tule and Riocito. The Tule, which is the larger, begins its easterly course at the northerly part of a cordon of low hills, known as the Sierrita de los Guineos.

It follows in this direction until below Guasdual, 15 kilometers from the Sierra de Tule, and then turns to the NE. for 30 kilometers, passing Irragori and arriving at the swamps of Tule, where it deposits a portion of its water. From this swamp its course is to the north for more than 30 kilometers, and it then empties into the river Tocuy at the distance of one league from Cano Negro.

The river Riocito, commencing about 15 kilometers from the Tule, follows approximately the same course as the latter until its junction with the Tocuy.

Neither the Sierra de Tule nor these two rivers are found on the map of the state constructed by Codazzi previous to 1830, nor in other maps made subsequently, all of which, however, have for a basis the work of Codazzi. Besides the range known as the Sierrita de los Guineos there are two others of slight elevation and somewhat distant one from another, the one beginning near the river Tule and the other near Los Ranchos de Guasdual.

The general direction of the road from Maracaibo to Irragori is from east to west, with a very slight northerly inclination, the distance being about 80 kilometers. The road is almost level, with a barely perceptible decline from the Sierra to the lake. A cart road could be easily constructed, and should a railway be projected, there would be close at hand the best class of wood for that purpose.

At the beginning of the exploration of the district situated between the Sierra de Tule and the river of the same name, attention was drawn to the numerous croppings of asphalt noticed at the foot of the Sierra de Guasdual. These croppings begin above Matuzalen and follow parallel to the Sierra on its eastern side as far as its extremity. All these deposits of asphalt are found in various stages of condensation, none, however, having the solidity of those of San Timoteo and the swamp of Mene on the east coast of the lake. The deposit of Matuzalen is the principal, having 60 meters of length and from 10 to 15 of breadth, and the force with which it sprouts up raises it more than half a meter above the level of the ground. At a distance of 30 kilometers east of Irragori, near the road leading to Maracaibo, and on an estate called Matapalo, is found a large asphalt deposit of an area of about 6,000 square meters.

COAL DEPOSITS.

It is the abundance of carboniferous deposits, however, which gives the greatest importance to the territory explored. At little more than the distance of one kilometer from the river Tule, near Los Ranchos de Guasdual, was found the first view of coal among the many discovered during the exploration. From this point, for a distance of five kilometers, exist fourteen veins more of the same mineral visible in the banks of the river, many of them measuring from 10 to 30 feet in diameter, and with an apparent direction of NNE and SSW. A number of these veins traverse the bed of the river at a depth of more than 3 meters, and it is probable that they extend a long distance on the other side.

Continuing the exploration along the river for a distance of 10 kilometers, it may be confidently asserted that its banks, as far as the foot of the Sierra, are an almost homogeneous composition of the same mineral visibly cropping out with scarcely any interruption. These croppings are also visible at various points of the banks of the creeks which empty into the Tule and Riocito, and abound in the last named river for a distance of more than 12 kilometers.

In view of these facts, it may be safely affirmed that in that part of the territory of the state included between the Sierra de Tule, the river of the same name, the Sierra de Guasdual, and a line drawn from the extremity of the latter to the Sierra de Tule, there exists a carboniferous formation which occupies an approximate area of 300 square kilometers.

Three of these coal veins are in constant combustion, the causes for which, and the date of commencement, are unknown. The first of these three is situated on the right bank of Algibe Creek, about 1 kilometer from Los Ranchos de Guasdual. It does not eject either smoke or flame, and its state of combustion is revealed only by the elevated temperature of the spot.

The second ignited vein is upon the left bank of the river Tule, 6 kilometers distant from the before mentioned Ranchos de Guasdual. At a distance of 15 or 18 feet above the level of the river there is a small fissure, measuring about 18 by 6 inches, from which smoke is constantly issuing. To the right and left of this crevice are several smaller ones, which do not eject smoke, but which give out an intense heat, showing the activity of the combustion.

The third vein is found close to the Sierra, on the bank of a creek, and at a short distance from the river Tule. From it smoke is constantly issuing, accompanied frequently by flames, whose brilliancy, it is said, may be distinguished, on clear nights, from localities only a few miles west of Maracaibo. Many circumstances unite to confirm the belief that this is the volcano heretofore mentioned. All this coal is of one quality, and of the bituminous variety. It is very similar to the cannel coal of England, although perhaps of less density, and containing less bitumen, and appears free from sulphur and other substances which many other coals contain. It burns freely in the open air, almost without smoke or sparks, producing a bright and clear flame, with a sufficiently intense heat. It does not "clink" or disintegrate to any great extent in the process of combustion, and leaves a very small residue of ashes. It is believed that this coal is far superior to any other as yet discovered in Venezuela, and it is to be regretted that the state has not sufficient resources to undertake the working and development of this wealth lying less than 100 kilometers from Maracaibo.

No mine in Venezuela offers advantages equal to those of Tule, not only on account of the excellent quality and extraordinary abundance of the coal, but also from the facility of working. All the veins are found at such a slight depth below the surface that nothing more than trenches are needed for their development. In only one locality, and for but a short distance, would galleries be necessary, and these could be easily run both straight and transversely, and in no part of the carboniferous territory would it be necessary to erect machinery to raise the coal to the surface.

Upon considering the extraordinary size of the veins of coal which cross the river Tule, the idea occurs that the beginning of this extensive carboniferous formation may be found at a considerable distance, and it would be interesting to decide the following questions:

1. To what distance do the croppings to the north of the river Riocito extend ?
2. Whether the Sierra de Tule contains coal deposits equal or similar to those already discovered.
3. Whether the carboniferous formation extends to the south of the river Tule as far as the Sierra of Perija.

If the formation is also found in the last mentioned range, there can be no doubt that there is the basis of all these deposits. In the department Guzman Blanco, bounded by the lake, the rivers Palmar, Santa Anna, and Sierra de Perija, are found a considerable number of asphalt deposits, and a coal formation at the foot of the Sierra, visible in two large crossings situated south of the town of Machiques, between Rio Negro and Santa Anna.

At La Paja, near the river Apon pieces of amber have been discovered, but no special investigations have been made respecting the possible abundance of this substance.

PETROLEUM DEPOSITS.

That part of the department Colon situated between the rivers Santa Anna, Zulia, and the Sierra of the Colombian frontier is very rich in asphalt and petroleum.

The information which we have regarding this extensive and interesting section, which is an uninhabited forest, is derived chiefly from the reports of the searchers for balsam copaiba, which abounds in this region, although the following data are taken from the personal observations of an American gentleman who made a special exploration. Near the Rio de Oro, and at the foot of the Sierra, there is a very curious phenomenon, consisting of a horizontal cave, which constantly ejects, in the form of large globules, a thick bitumen. These globules explode at the mouth of the cave with a noise sufficient to be heard at a considerable distance, and the bitumen, forming a slow current, falls finally into a large deposit of the same substance near the river bank.

The territory bounded by the rivers Zulia, Catatumbo, and Cordillera is rich in deposits and flows of asphalt and petroleum, especially toward the south, where the latter is very abundant. At a distance of little more than 7 kilometers from the confluence of the rivers Tara and Sardinete there is a mound of sand of from 25 to 30 feet in height, with an area of about 8,000 square feet. On its surface are a multitude of cylindrical holes of different sizes which eject with violence streams of petroleum and hot water, causing a noise equal to that produced by two or three steamers blowing off simultaneously. For a long distance from the site of this phenomenon the ground is covered or impregnated with petroleum. The few explorers for balsam copaiba who have visited this place call it the *infernito* (little hell).

Among other items it is stated that from one only of these streams of petroleum was filled in one minute a receptacle of the capacity of 4 gallons, which for one hour would be 240 gallons, or 5,760 gallons in twenty-four hours ; and even supposing this calculation to be somewhat exaggerated, the fact remains that such a considerable number of petroleum jets in constant active operation must produce daily an enormous quantity. This petroleum is of excellent quality, with a density of eighty-three degrees, which is a sufficient grade for foreign markets.

Considering the immense amount of inflammable gases which must be given out by the flows and deposits of petroleum described above, it may be easily believed that this has a direct bearing upon the phenomenon known since the conquest as the "Faro" of Maracaibo. This consists of constant lightning, without explosion, which may be observed toward the southward from the bar, at the entrance to the lake, and which Codazzi, in his geography, explains as being caused by the vapors arising from the hot water swamps situated about one league to the eastward of the mouth of the Escalante River, at the southern extremity of the lake.

In the department Sucre, at the foot of the mountains, are found various croppings of asphalt and coal. Near the mountains, and not far from the river Torondoy, there are various flows of a substance which appears to be distinct from either asphalt or petroleum. It is a liquid, of a black color, with little density, and strongly impregnated with carbonic acid, and its apparent identity with a substance met with in the United States among the great anthracite deposits leads to the belief that there also may be discovered formations of that valuable mineral.

The foregoing data have been collected to call attention to the possibilities of successful investment of capital. As I have already reported to the department, with detailed explanations, British capitalists have captured a flourishing petroleum industry, situated in the first mountain range south of the lake.

The state of Zulia, in which are situated all the deposits of coal, asphalt, and petroleum herein mentioned, is as yet free from any monopolistic concession ; but this cannot last forever, and it remains to be seen whether American enterprise and capital will eventually take in hand the development of what should be a most profitable industry, or whether, as is usually the case in South America, Europeans will reap the fruits of information furnished, perhaps, primarily, by the representatives of the United States. There are many other natural advantages in Venezuela which could be developed without excessive expense, and with an almost absolute certainty of most profitable results.

The government is disposed to extend every reasonable encouragement and protection, and to-day various European corporations are drawing large incomes from the capital which they had the courage to invest in this country. E. H. PLUMACHER, U. S. Consul.

Maracaibo, February 8, 1888.

THE vanilla bean used by druggists and confectioners is the costliest bean on earth. It flourishes in Mexico, chiefly in Papantla and Misantla. It grows wild, and is gathered and marketed by the natives. Just as they come from the forest the beans sell at $10 or $12 per thousand. After the beans are dried and cured they are worth from $7 to $12 per pound, according to quality.

A STUDY ON WHIRLWINDS.

I.

THE theories in regard to the formation of whirlwinds, with which is connected the history of waterspouts, have given rise to many discussions and controversies. It is not a theoretical study that we are about to present to our readers, but a simple observation of well examined facts. It is not easy to be in a position to see a whirlwind close by, but Prof. H. Gilbert, of the Colbert Municipal School, has had this good fortune, and has sent a detailed note, accompanied with very good sketches. We reproduce both herewith.

On Sunday, May 13, 1888, toward half past three o'clock in the afternoon, I happened to be with a few members of my family on the Vincennes field of maneuvers, on the road called Pyramid, at the angle of the roads that lead to the farm and pheasantry. The heat was overpowering, the sky very clear, and the air absolutely calm. On arriving at within 15 or 20 feet of the place marked A in Fig. 1, we heard a strange, very pronounced noise, comparable to that which would be made by a colossal top in revolving; and which seemed so much the more inexplicable in that there was nothing to be conceived of as the cause of it. The atmosphere remained perfectly transparent, and the country, being entirely flat, offered nothing in particular to the eye. Meanwhile we perceived a gyratory motion of extreme violence at A. The road was very dusty, and the dust and *debris* of all sorts seemed to be carried along in a very swift revolving motion (Fig. 1). It was then that the whirlwind assumed a perceptible form—that of a large funnel placed in its natural position. The sand, carried along by the gyratory motion, was, in ascending, gradually distributed over the periphery of the vortex, thus making it seem as if the latter was rising toward the clouds. The apparent dimensions of the vortex then increased quite rapidly through the incessant influx of dust, which, progressively rising in helicoidal trajectories, ended by collecting at a height of 75 feet in an opaque cloud of globular form (Fig. 2).

But the vortex had in addition a motion sideways incomparably slower than the gyratory one. It moved in its entirety without bending—a fact that may be attributed to the perfect calmness of the atmosphere or to the slight velocity of the horizontal motion.

FIGS. 1 AND 2.—WHIRLWIND OBSERVED AT VINCENNES.

The first vortex, that shown in Fig. 2, lasted two or three minutes at the most. Reaching B, the point began to oscillate in a vertical direction, or to *dance*, if I may so express myself, and finally left the earth and disappeared, and the vortex with it. At the upper part, the only thing that remained was a vague nebulosity, which soon vanished in its turn. In our sketch (Fig. 2), the arrow, f_1, indicates the direction of the horizontal motion, and f_2 shows that of the gyratory motion of the vortex.

A few instants afterward, a second point began to appear. A vortex smaller than the other appeared and quite quickly traversed its trajectory, but this was but an ephemeral manifestation. It was not the same with the third and last vortex, which arose nearly at the same point, and which began the same series of phenomena already described, save the formation of a globular cloud that was less clearly visible. But such inferiority was compensated for by a superiority—that of lasting longer, of describing a long trajectory, at least 300 feet in length, and, toward the end of its existence of five or six minutes, of exhibiting a remarkable phenomenon of segmentation. Reaching a certain spot, the point began to dance; then, all at once, five or six smaller points substituted themselves for the preceding and arranged themselves on a circumference of some yards in diameter. Each of these points whirled around in the same direction as the former large one. Moreover, as a whole, they had a circular motion around the circumference on which they were distributed. Finally, the general rectilinear lateral motion ceased. At the end of a few seconds, the points decreased, danced, arose, and disappeared. Then everything ceased.

The idea then occurred to me to ascertain approximately the temperature of the earth in the road where these phenomena had made their appearance. I applied the back of my hand to the dust and felt a feeble sensation of coolness, and this gave me an idea of the temperature sought. I afterward examined the furrow made by the point of the first vortex. The earth seemed to be confusedly excavated for a uniform width of some inches. Aside from the furrow, I saw no trace whatever of a convergent movement of the dust capable of resulting from a suction toward the axis of the

whirlwind. Finally, to complete these data, the general state of the atmosphere did not seem to be affected in its equilibrium by the advent of these phenomena.

Mr. Gilbert, who was occupied in studying the phenomenon that he witnessed, did not think of approaching as near as possible in order to ascertain the direction of the vertical motion of the vortex. Under analogous circumstances, an observer might assuredly feel the vortex and obtain something decisive as to the ascending or descending motion of the column of central air. But vortices are not affairs that can be

Fig. 3.—OBSERVER IN A VORTEX.

usually approached without danger, and the small ones that occur in our roadways generally give too fugitive an image of the phenomenon. It is therefore vain to hope that evidence of this kind can be obtained.

II.

It would be interesting to ascertain the direction of the vertical motion of the air in the vortex. We did not then know that such an observation had already been made, and that, too, under most remarkable conditions, as may be judged of from the following communication, sent us by Mr. H. Duhamel, vice-president of the Isere section of the French Alpine Club:

"I have witnessed the formation, motion and disappearance of at least fifteen whirlwinds, either of dust or snow, of the height and form of that of Vincennes, and all absolutely corresponding with Prof. Gilbert's description, but I have never seen the lifted material collected into a dark cloud of globular form as in the whirlwind observed on the 13th of last May. In my observations, the upper extremity always formed a sort of plume. All the whirlwinds that I have seen have had a somewhat regular horizontal motion, the gyratory direction of which seemed to be from right to left. I have placed myself within vortices of various dimensions (Fig. 3), and have always distinctly felt within, as at the sides, the undoubted sensation of an ascending motion. Moreover, I am certain that the lifted substances are distributed throughout the entire

Fig. 4.—VELOCIPEDIST PASSING THROUGH A VORTEX.

mass of the vortex. I have not seen this, but have felt it by my nostrils when there was dust, and by contact with my face when there was snow or straw.

"There is another thing to be noted: On placing myself in the center of a vortex, the latter has never disappeared; I have three or four times amused myself upon different roads . . . . by passing with very great rapidity through a vortex (absolutely of the same size as that of Vincennes), and, despite the strong current of air caused by my motion on a velocipede, high and wide, the vortex has in nowise been affected thereby (Fig. 4).

"I ought to add that for the fifteen years that I have traveled over the road from Gieres to Grenoble it has always been near the same place that I have seen the various vortices form which I have observed months apart. Now, this place, situated in the center of the plain of Graisivaudan, seems to be submitted (at least in the somewhat high parts of the atmosphere) to a powerful current of air coming from the northeast through a pass in the Chartreuse debouching in the valley of the Isere, at an altitude of about 2,500 feet above the latter.

"Mr. Gilbert's description is perfectly accurate, and his observation agrees with all of my own. The aspect of the furrow made across or in the dusty earth is scrupulously exact. It marks, after a manner, the oscillations of the base of the vortex in its double horizontal and gyratory motion.

"The vortices that I have observed upon the high crests of our mountains (where the snow is usually

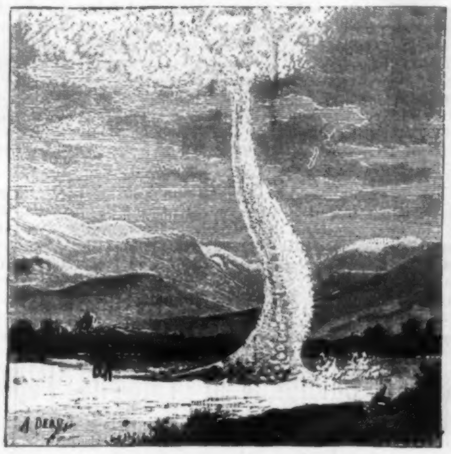


Fig. 5.—SNOW VORTEX IN THE ALPS.

closely packed, and allows the vortices to raise nothing more than a sort of very dry frost of slight density) exhibit on a small scale the form of those seen by me upon the dusty highways, say that of an inverted cone. On the contrary, the vortices of snow that I have met with on great plateaux, where the snow was abundant and dry, have exhibited the aspect of the terrible sand vortices of the deserts (Fig. 5). From this, it seems to me that the density of the substances lifted sensibly modifies the general form of the vortex, to begin with its very base of suction, which is sharp in this case and much widened in the other. The existence of conical vortices lifting snow and sand evidently indicates an infinitely greater intensity in the meteorological phenomenon.

"Let me, in conclusion, impart to you my personal opinion as to the formation of these interesting and often terrible phenomena. (1) Everything goes materially to demonstrate that the vortex itself presents a force of ascension, and that in its whole mass the current flows upward. (2) In mountainous regions, vortices form by preference in certain places—rounded crests, wide and open eminences, hemmed-in valleys, high plains, and points in valleys situated beneath currents of air coming from Alpine defiles debouching above them."

Mr. D. Colladon, of Geneva, addresses the following note to us, which we take pleasure in publishing:

"I have read Prof. Gilbert's note on the whirlwind observed by him at Vincennes, with the greatest interest. There are several things to be noted in his remarks, and the most important are the formation of the point of the vortex and the direction of rotation, which was from left to right.

"Will you allow me to recall here what I wrote in 1879 upon a vortex whose every phase I followed for some minutes?

"One fine day in July, and in very calm weather, I was passing along the Coulouvreniere Boulevard, in Geneva, near a gravelly place upon which a number of pieces of linen, of various sizes, were lying exposed to the sun. All at once a whirlwind with vertical axis two or three yards in diameter, and made very visible by the rotation of a cloud of dust, passed over the surface covered with linen, set a portion of the latter in revolution, and carried it up with terrific speed to a great height above the roofs of the city, and caused the pieces to describe continuous spirals that became more and more divergent. Finally, at an elevation of at least 2,000 or 2,200 feet, the objects separated and dispersed in various directions. It was undoubtedly a vortex with an ascending gyratory motion. In the beginning, the column appeared to have the form of an inverted cone, and it was to the interior of this that all the objects had been attracted and then carried along by the impulsion of the air. These momentary vortices may be very frequent during the warm and calm days of spring and summer, but they are not visible unless they meet with light substances and much dust at their origin; and they are rarely observed.

"Had not the one that I observed carried along with it some pieces of linen that allowed me to see it at a great height, it would have disappeared at 100 or 125 feet, just as smoke disappears at a certain elevation.

"These vortices, in which the air rises spirally, have been seen on dusty plains in various countries, and generally in calm weather. Their form has been compared by Humboldt to a funnel whose extremity rests upon the ground. In his "Pictures of Nature," he speaks of vortices of this kind observed in the Llanos—a vast dry plain of South America, near Venezuela.

"Mr. Stephenson has witnessed the same phenomena in the province of Behar, on the dusty plains near the Ganges. He describes two enormous columns of dust which formed near the confluence of the Ganges and Soane, which were more than 12 feet in diameter and the summit of which was lost in the atmosphere."

Mr. Adrien Arcelin addresses an analogous observation from Saint Sorbin. It is about a vortex witnessed by him in August, 1873, near Solutre.

"A quire of straw paper that I used for wrapping up objects gathered from excavations, and which was lying on the ground at our feet, was carried off into space. All the sheets separated from each other and began to rise and turn round and round in helicoidal trajectories that continued to widen. Nothing was more curious than to see these twenty-four large sheets of paper whirling in the air like a flock of big birds. They flew way beyond the summit of the rock, which was 260 feet above the spot where we were standing, and became lost in the sky toward Vergissen. The vortex had therefore moved in the direction of the northwest. It was 4 o'clock in the afternoon. The weather was delightful and very warm, the sky was very clear, and the air perfectly calm.

"Our ten laborers, who were sitting on the ground and eating, at about sixty feet from the place, absolutely perceived nothing. There was no movement of dust, the ground being covered with grass, and had it not been for the paper, which was there by accident, several features of the phenomenon would have escaped us."—*La Nature.*

FUNGUS DISEASES IN PLANTS—THEIR TREATMENT.

In Circular No. 5 of the botanical division of the Department of Agriculture, Prof. Scribner gives the following information:

The diseases in plants caused by fungi are simply the effects produced by other plants of parasitic habits, and we must keep the two—the parasite and the plant attacked—distinct in our minds in our efforts to protect the one from the other.

For some of these so-called diseases there is no remedy but the knife or the complete destruction of the infested plant. It is important to understand the cases of this character, not only that we may avoid wasting time and money in vain efforts to treat them otherwise, but in order that prompt action may be taken and sources of infection be quickly destroyed, for all fungus diseases may be regarded as infectious. Those remedies or preventives which have apparently yielded positive results are here enumerated, together with directions for their preparation, etc.

Fungi living within the tissues of the host must be prevented from gaining an entrance to these tissues; fungi which live upon the surface of plants or having their bodies soon exposed through the breaking up of the epidermis, like the apple scab fungus or the fungus of bird's eye rot of grapes, may be treated for cure.

Destructive treatments are available between the periods of vegetation (winter season), and consist in destroying all infectious material and in washing the plants to be protected with strong caustic solutions, *e. g.*, solutions of sulphate of iron or copper and sulphuric acid.

During the growing season the strength of the solutions used is governed by the power of the green plant tissues to resist their action. In the early part of the season, while the shoots and leaves are yet tender, weaker solutions than those which may safely be applied later in the season must be employed. Sulphur alone, applied when the weather is very hot and the sun bright, may cause a burning of the foliage. The same is true of sulphatine and also of eau celeste.

Avoid making the applications excessive; do not drench the plants with the fluids nor plaster them with the powders. With a suitable spraying apparatus, which projects a fine, mist-like spray, merely wet the plant surfaces, and employ bellows which will discharge the powder evenly and in such a manner that the plants may be enveloped in a cloud of dust, which, settling upon all parts, becomes just perceptible.

For small plantations and general vineyard use, the knapsack form of sprayer, having the reservoir and pump combined, to be carried on the back of the operator, is the best. For spraying fruit trees, more powerful appliances are required.

Nixon's Climax nozzle is excellent for spraying clear liquids, but its use demands considerable power in the pumps.

KNAPSACK APPARATUS WITH BELLOWS FOR POWDERS, USED IN THE VINEYARDS OF FRANCE.

The Vermorel modification of the eddy chamber or cyclone nozzle is a most excellent pattern for both clear and pasty or thick liquids. The degorger combined with it renders the spraying of the latter possible.

LIQUIDS.

Simple Solution of Sulphate of Copper.—For treatment of downy mildew and oidium of the vine. For treatment of downy mildew and black rot of the grape.

Dissolve 1 pound of pure sulphate of copper in 25 gallons of water.

Simple Solution of Sulphate of Copper.—For soaking seeds previous to sowing to destroy the spores of smuts.

Solution in water, 5 to 8 pounds to 10 gallons.

Copper Mixture of Gironde, Bordeaux Mixture.—For treatment of mildew. For downy mildew and black rot of the grape. For blight and rot of the tomato and potato.

Original formula.—Dissolve 16 pounds of sulphate of copper in 22 gallons of water, in another vessel slake 30 pounds of lime in 6 gallons of water. When the latter mixture has cooled, it is slowly poured into the copper solution, care being taken to mix the fluids thoroughly by constant stirring. It is well to have this compound prepared some days before it is required for use. It should be well stirred before applying. A solution containing the ingredients in the following proportions has been recommended for general use: Sulphate of copper, 4 pounds; lime, 4 pounds; water, 12 gallons. The copper is dissolved in 16 gallons of water, while the lime is slaked in 6 gallons. When cool, the solutions are mixed as described above.

Eau Celeste, Audoynaud Process.—For downy mildew. For treatment of downy mildew and black rot of the grape. For treatment of mildew and anthracnose. For blight and rot of the tomato and potato. For apple scab.

Dissolve 1 pound of sulphate of copper in 2 gallons of hot water; when completely dissolved and the water has cooled, add 1½ pints of commercial ammonia (strength 22 deg. Baume); when ready to use dilute to 22 gallons. The concentrated liquid should be kept in a keg or some wooden, earthen or glass vessel.

Modified Formula.—Sulphate of copper, 2 pounds; carbonate of soda, 2½ pounds; ammonia (22 deg. Baume), 1½ pints; water, 22 gallons.

Dissolve the sulphate of copper in two gallons of hot water, in another vessel dissolve the carbonate of soda in a similar manner; mix the two solutions, and when all chemical reaction has ceased, add the ammonia; dilute to 22 gallons.

Solution of Ammoniacal Carbonate of Copper.—For peronospora of the vine.

Prepared as follows: Into a vessel having a capacity of two quarts or more pour one quart of ammonia (strength 22 deg. Baume), add 3 ounces carbonate of copper, stir rapidly for a moment and the carbonate of copper will dissolve in the ammonia, forming a very clear liquid. The concentrated liquid thus prepared may be kept indefinitely. For use dilute to 22 gallons.

Sulphate of Iron.—For anthracnose.

Simple solution in water 4 to 8 pounds to the gallon, to be used only as a wash.

Sulphide of Potassium, Liver of Sulphur.—For mildew in greenhouses. For mildew on roses. For oidium and erinose of the vine. For orange leaf scab. For celery leaf blight. For pear and apple scab.

Solution in water, ½ to 1 ounce to the gallon.

Solution of Hyposulphite of Soda.—For apple scab. For celery leaf blight. For orange leaf scab.

Simple solution of 1 pound of the soda in 10 gallons of water. Must be used at once.

Liquid Grison. Eau Grison.—For mildew on grape vines. For powdery mildew.

Prepared by boiling three pounds each of flowers of sulphur and lime in 6 gallons of water until reduced to 2 gallons, when settled pour off the clear liquid and bottle it. When used, mix 1 part of the clear liquid in 100 parts of water.

Milk of Lime.—For peronospora of the vine. For anthracnose.

Simple solution in water, 2 to 6 parts lime to 100 parts water.

Phenic Acid. Carbolic Acid.—For powdery mildew of the vine.

Solution in water one half pint to 10 gallons.

POWDERS.

Sulphur.—For grape mildew. For powdery mildew of the vine.

Sulphur and Lime.—For treatment of anthracnose during the growing season.

A mixture of equal weights sulphur and lime.

Blight Powder and Sulphur.—For simultaneous treatment of oidium and the downy mildew. For downy mildew of the vine. For tomato and potato blight and rot.

Prepared by thoroughly mixing from 3 to 8 pounds of anhydrous sulphate of copper with 90 to 100 parts of flowers of sulphur.

Sulphatine, the Esteve Process.—For the treatment of mildew. For the treatment of downy mildew and black rot of the grape. For the treatment of the tomato and potato for blight and rot.

Mix 2 pounds of anhydrous sulphate of copper with 20 pounds of flowers of sulphur and 2 pounds of air-slaked lime. The proportions may be varied.

Skawinski's Powder.—For simultaneous treatment of oidium and downy mildew of the vine. For treatment of mildew.

Mix 22 pounds of finely powdered sulphate of copper with 33 pounds of soot or alluvial earth and 165 pounds of coal dust.

Sulfostealite or Cuprique Steatite.—For the treatment of mildew (*Peronospora*).

An exceedingly fine bluish powder composed of steatite, or talc, and sulphate of copper, the proportion of the latter substance amounting to about 10 per cent. Very easily applied; this is considered the most adherent of all the powders used for these purposes.

David's Powder.—For downy mildew and black rot of the grape. For mildew and anthracnose.

Dissolve 4 pounds of sulphate of copper in the least possible amount of hot water, and slake 16 pounds of lime with the smallest quantity of water required. When the copper solution and slaked lime are completely cooled, mix them together thoroughly; let the compound dry in the sun, crush and sift. Apply with a sulphuring bellows of some description furnished with an outside receptacle for containing the powder. The copper coming in contact with the disease will very soon destroy it.

Podechard's Powder.—For the downy mildew of the vine. For the treatment of mildew and anthracnose.

Air, slaked lime, 225 pounds; sulphate of copper, 45 pounds; flowers of sulphur, 20 pounds; ashes, 30 pounds.

Dissolve the sulphate of copper in the water; when thoroughly dissolved, pour the solution upon the lime, which is surrounded by the ashes to keep the liquid from spreading; after twenty-four hours add the sulphur, thoroughly mix the compound, ashes and all, and when dry sift through a sieve with meshes of one-eighth of one inch. This preparation may be made several months before it is required for use.

REFRIGERATING MIXTURES OBTAINED WITH SOLID CARBONIC ACID.

By L. CAILLETET and E. COLARDEAU.

THE authors show that in a mixture of flocculent carbonic acid and ether the latter does not, as commonly supposed, act merely by establishing a more complete contact with the body to be refrigerated, but that cold is produced by the solution of the carbonic acid in the ether. Solid carbonic acid alone produced a temperature of −60° under the ordinary atmospheric pressure, and of −76° in a vacuum. A mixture of solid carbonic acid and ether gave, under ordinary atmospheric pressure, a temperature of −77°, and in a vacuum of −103°. The experiment was repeated with other solvents. Methyl chloride and liquefied sulphurous acid gave each −82°, acetamylic ether −78°, phosphorous trichloride −76°, and absolute alcohol −72°. In a mixture of methyl chloride and solidified carbonic acid in a vacuum a temperature of −106° was observed.

FROM experiments made in the Danish navy, it appears that there is but little difference in the efficiency of the two bladed and four bladed propellers, the same blades being used in each case, so that the loss of one-half of the propeller surface was balanced by the lessened friction. At speeds greater than 12 knots, however, the vibration with the two bladed propeller was excessive.

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